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Dioxin Analysis of Philadelphia Northwest Incinerator. Summary Report
Volume 2. Appendices A - F

Midwest Research Inst., Kansas City, MO

Prepared for

Environmental Protection Agency
Philadelphia, PA

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16. ABSTRACT

A study was conducted by US EPA Region 3 to determine the dioxin-related impact of the Philadelphia Northwest Incinerator on public health. Specifically, it was designed to assess quantitatively the risks to public health resulting from emissions into the ambient air of dioxins as well as the potential effect of deposition of dioxins on the soil in the vicinity of the incinerator. Volume 1 is an executive summary of the study findings. Volume 2 contains contractor reports, laboratory analysis results and other documentation.

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SUMMARY REPORT

DIOXIN ANALYSIS OF PHILADELPHIA

NORTHWEST INCINERATOR

APPENDICES A - F

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION III, PHILADELPHIA

JANUARY 1986

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EMISSIONS TEST REPORT:
CITY OF PHILADELPHIA NORTHWEST AND EAST CENTRAL MUNICIPAL INCINERATORS

By

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VOLUME I - TECHNICAL REPORT

EPA Contract No. 68-02-3891
MRI Project No. 8281-L(1)

October 31, 1985

For

Mr. Victor Guide
Region III
U.S. Environmental Protection Agency
841 Chestnut Street
Philadelphia, Pennsylvania 19146

PREFACE

This final report presents the results for emission tests conducted by Midwest Research Institute at the City of Philadelphia Northwest and East Central Municipal incinerators. The objective of the project was to quantify the polychlorinated dibenzo-p-dioxin and polychlorinated dibenzofuran emissions from these two facilities. The work was conducted under EPA Contract No. 68-02-3891. Primary responsibility for the project resided within the Environmental Systems Department with analytical support provided by the Chemical and Biological Sciences Department. Mr. Roy Neulicht was project leader. Mr. Tom Walker was responsible for supervising all emissions testing; Drs. John Stanley and Tom Capps acted as task leaders for the analytical aspects of the project. Ms. Carol Green, Mr. Scott Meeks, and Mr. Jack Balsinger monitored quality assurance for the project.

Approved for:

MIDWEST RESEARCH INSTITUTE

Chatten Cowherd

Chatten Cowherd, Director
Environmental Systems Department

October 31, 1985

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LIST OF ABBREVIATIONS AND SYMBOLS

ABBREVIATIONS

CEMS -- Continuous Emission Monitoring System
dscf -- dry standard cubic feet (68°F, 29.92 in.Hg)
EC -- east central incinerator
ESP -- electrostatic precipitator
°F -- degrees Farenheit
ft -- feet
g -- gram
gr -- grain
hr -- hour
kg -- kilogram
lb -- pound
M3 -- Reference Method 3 (40CFR 60 Appendix A)
MM5 -- Method Method 5
mg -- milligram
ng -- nanogram
Nm^3 -- Normal cubic meter (20°C, 760 mmHg)
NW -- northwest incinerator
ppm -- parts per million (volume/volume)
QA -- Quality Assurance
sec -- second

SYMBOLS

CO -- carbon monoxide
CO_2 -- carbon dioxide
HCl -- hydrogen chloride
HxCDD -- hexachlorodibenzo-p-dioxin
HxCDF -- hexachlorodibenzofuran
HpCDD -- heptachlorodibenzo-p-dioxin
HpCDF -- heptachlorodibenzofuran
NO_x -- nitrogen oxide
O_2 -- oxygen
OCDD -- octachlorodibenzo-p-dioxin
OCDF -- octachlorodibenzofuran
PCDD -- polychlorinated dibenzo-p-dioxins
PCDF -- polychlorinated dibenzofurans
P_5CDD -- pentachlorodibenzo-p-dioxin
P_5CDF -- pentachlorodibenzofuran
SO_2 -- sulfur dioxide
TCDD -- tetrachlorodibenzo-p-dioxin
TCDF -- tetrachlorodibenzofuran
THC -- total hydrocarbon
% -- percent

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SECTION 1.0

INTRODUCTION

The primary objective of this project was to quantify emissions of polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) at four City of Philadelphia municipal incinerator units operating under normal conditions. The project involved sampling and analysis for PCDDs and PCDFs at the City of Philadelphia's Northwest (NW) Unit 1, NW Unit 2, East Central (EC) Unit 1, and EC Unit 2.

Work at all four incinerator units included sampling and analyses of ESP fly ash and incinerator bottom ash for PCDDs and PCDFs; continuous monitoring of stack gas emissions for carbon monoxide (CO), carbon dioxide (CO_2), oxygen (O_2), total hydrocarbons (THC), nitrogen oxides (NO_x), and sulfur dioxide (SO_2); and recording of incinerator operating parameters. In addition, the project included emissions sampling by Modified Method 5 (MM5) to determine the PCDDs, PCDFs, total particulate matter, and hydrogen chloride (HCl) stack emissions from NW Unit 1 and NW Unit 2. Two identical Modified Method 5 (MM5) sampling trains were used during the test program; these trains are referred to as the "A" train and the "B" train. One sample train was analyzed for PCDDs and PCDFs; the other train was analyzed for particulate matter and HCl.

Although stack gas emissions of PCDD, PCDF, and particulate were not sampled from the EC units because of limited project resources, the NW and EC units are very similar in design. The intent of the study was to gather the monitoring data (CO, CO_2, O_2, and THC), opacity observations, and process operating data from all four units to verify that both the EC and NW units were operating similarly. If the units operate in a similar manner and the monitored emissions are similar, one could hypothesize that the PCDD and PCDF emissions are similar (same order of magnitude). This report presents the results of the emissions tests, but does not compare data from the different units, nor draw any conclusions regarding the measured emissions levels.

The emission tests were conducted by MRI during the period of February 27 through March 7, 1985. Table 1 is a log of the test runs conducted during the study.

A summary of results is presented in Section 2. Section 3 presents a brief description of the facilities tested and a summary of the process operating parameters during the test period. Section 4 presents the complete results of the emissions tests and provides a discussion of the results; quality assurance results also are summarized in this section. Descriptions of the sampling and analysis protocols are provided in Section 5.

The appendices for this project are presented in eight separate volumes. The contents of the appendices are listed in the Table of Contents.

TABLE 1. TEST LOG

Run No.	Date	Facility[a]	Start time	End time	Type of test
1A	2/27/85	NW2	1545	1721	Dioxin
1B	2/27/85	NW2	1547	2006	Particulate/HCl
1A/B	2/27/85	NW2	1545	2006	CEMS[b]/fly ash/bottom ash
2A	2/28/85	NW2	1200	1712	Dioxin
2B	2/28/85	NW2	1212	1710	Particulate/HCl
2A/B	2/28/85	NW2	1200	1712	CEMS/fly ash/bottom ash
3A	3/01/85	NW2	0935	1425	Particulate[c]/HCl
3B	3/01/85	NW2	0941	1427	Dioxin
3A/B	3/01/85	NW2	0935	1427	CEMS/fly ash/bottom ash
4A	3/02/85	NW1	1130	1710	Dioxin
4B	3/02/85	NW1	1132	1712	Particulate/HCl
4A/B	3/02/85	NW1	1130	1712	CEMS/fly ash/bottom ash
5A	3/03/85	NW1	0940	1410	Dioxin
5B	3/03/85	NW1	0942	1412	Particulate/HCl
5A/B	3/03/85	NW1	0940	1412	CEMS/fly ash/bottom ash
5C	3/03/85	NW2	1610	1902	Particulate/HCl
6A	3/05/85	NW1	1340	1850	Dioxin
6B	3/05/85	NW1	1342	1852	Particulate/HCl
6A/B	3/05/85	NW1	1340	1852	CEMS/fly ash/bottom ash
7	3/07/85	EC1	1150	1516	CEMS/fly ash/bottom ash
8	3/07/85	EC2	1646	2012	CEMS/fly ash/bottom ash

[a] NW1 = Northwest Unit No. 1
NW2 = Northwest Unit No. 2
EC1 = East Central Unit No. 1
EC2 = East Central Unit No. 2

[b] Continuous emission monitoring for O_2, CO_2, CO, THC, SO_2, NO_x.

[c] Probe liner broken at end of test; post test leak check failed.

SECTION 2.0

SUMMARY OF RESULTS

Table 2 summarizes the test results for all four incinerator units. Total tetra-octa chlorinated dibenzodioxin (PCDDs), total tetra-octa chlorinated dibenzofuran (PCDFs), 2,3,7,8-tetraCDD, and 2,3,7,8-tetraCDF results are reported for the stack emissions, electrostatic precipitator (ESP) fly ash, and bottom ash. Particulate matter, HCl, opacity, and continuous emission monitoring (O_2, CO_2, CO, THC, SO_2, and NO_x) results also are presented.

For the two NW incinerator units, the measured total tetra-octaCDD concentrations range from 1,000 to 4,700 nanograms/normal cubic meter (ng/Nm^3), resulting in measured emission rates of 41,000 to 170,000 ng/sec; total tetra-octaCDF concentrations range from 1,000 to 5,000 ng/Nm^3, resulting in measured emission rates of 41,000 to 180,000 ng/sec.

Measured particulate matter concentrations corrected to 12% CO_2 range from 0.21 to 3.5 g/Nm^3 (0.09 to 1.5 gr/dscf). All measurements except Test 1B at NW Unit 2 were in the 0.21 to 0.43 g/Nm^3 (0.09 to 0.19 gr/dscf) range. Calculated particulate matter emission rates range from 13 to 175 kg/hr (29 to 385 lb/hr); without Test 1B, the range is 13 to 24 kg/hr (29 to 52 lb/hr). Measured HCl emission rates range from 7 to 32 kg/hr.

For the four incinerator units, the measured average oxygen concentration ranged from 13.4 to 16.6%, and the measured average carbon dioxide concentration ranged from 3.3 to 5.6%. Average carbon monoxide concentrations ranged from 16 to 240 ppm, while the average total hydrocarbon concentration ranged from less than 1 (< 1) ppm to 7 ppm.

TABLE 2. SUMMARY OF RESULTS

Facility:		Northwest Unit No. 1			Northwest Unit No. 2				East Central Unit No. 1	East Central Unit No. 2
Run No.:		4AB	5AB	6AB	1AB	2AB	3AB	5C	7	8
Test Date		3/02/85	3/03/85	3/05/85	2/27/85	2/28/85	3/01/85	3/03/85		
Process Data										
Avg. incinerator temp.	°F	1,910	1,770	1,760	1,730	1,740	1,700	1,750	1,840	1,890
Avg. indicated inclined grate speed	ft/hr	66	60	70	70	70	71	61	80	79
Avg. measured inclined grate speed	ft/hr	75	74	86	NM	NM	NM	73	101	84
Avg. measured horizontal grate speed	ft/hr	123	115	NM[a]	NM	NM	NM	144	147	160
Stack Emissions										
2,3,7,8-TCDD	ng/Nm^3	5.4	4.4	8.3[b]	~~0.8~~ 3.4	6.8	4.3	NM	NM	NM
	ng/sec	190	160	290[b]	~~33~~ 140	280	170	NM	NM	NM
2,3,7,8-TCDF	ng/Nm^3	27	14	35[b]	8.7	18	13	NM	NM	NM
	ng/sec	950	540	1,200[b]	350	760	520	NM	NM	NM
Total tetra-octa CDD	ng/Nm^3	1,300	1,100	4,700[b]	1,100	1,300	1,000	NM	NM	NM
	ng/sec	46,000	42,000	170,000[b]	42,000	54,000	41,000	NM	NM	NM
Total tetra-octa CDF	ng/Nm^3	1,600	1,200	5,000[b]	1,000	1,300	1,000	NM	NM	NM
	ng/sec	57,000	45,000	180,000[b]	42,000	54,000	41,000	NM	NM	NM
Particulate concentration corrected to 12% CO_2	g/Nm^3	0.31	0.25	0.21	3.5	0.33	0.43[c]	0.23	NM	NM
	(gr/dscf)	(0.13)	(0.11)	(0.09)	(1.5)	(0.14)	(0.19)[c]	(0.10)	NM	NM
Particulate matter, emission rate	kg/hr	19	15	12	175	19	24[c]	13	NM	NM
	(lb/hr)	(42)	(32)	(27)	(385)	(42)	(52)[c]	(29)	NM	NM
HCl	mg/Nm^3	244	145	246	48	72	175[c]	NM	NM	NM
	kg/hr	32	20	31	7.0	11	25[c]	NM	NM	NM
Avg. opacity	%	6.2	24.6	3.3	25.0	14.4	15.6	6.2	2.5	3.4
Avg. O_2	%	13.4	14.7	13.6	14.4	15.1	14.9	NM	15.3	16.6

(continued)

TABLE 2. (continued)

Facility:		Northwest Unit No. 1			Northwest Unit No. 2				East Central Unit No. 1	East Central Unit No. 2
Run No.:		4AB	5AB	6AB	1AB	2AB	3AB	5C	7	8
Avg. CO_2	%	5.5	4.8	5.6	5.2	4.4	4.5	NM	4.2	3.3
Avg. CO	ppm	238	240	204	150	193	202	NM	57	16
Avg. THC	ppm	3	2	7	6	5	< 1	NM	< 1	1
Avg. SO_2[d]	ppm	203	156	173	122	167	152	NM	40	26
Avg. NO_x	ppm	84	7[illegible]	96	93	79	81	NM	62	48
Fly Ash										
2,3,7,8-TCDD	ng/g	6.6	6.2[e]	3.9	5.0[e]	3.7	4.0	NM	3.0[e]	0.57[e]
2,3,7,8-TCDF	ng/g	13	11[e]	6.8	8.7[e]	6.3	9.0	NM	6.1[e]	1.4[e]
Total tetra-octa CDD	ng/g	1,900	2,100[e]	1,800	1,500[e]	1,000	850	NM	1,900[e]	720[e]
Total tetra-octa CDF	ng/g	1,300	1,600[e]	1,600	1,200[e]	900	1,300	NM	940[e]	270[e]
Bottom Ash										
2,3,7,8-TCDD	ng/g	1.5	0.59[e]	0.92	0.34[e]	0.79	0.83	NM	0.38[e]	0.02[e]
2,3,7,8-TCDF	ng/g	2.7	0.90[e]	1.5	0.56[e]	0.86	1.4	NM	0.29[e]	0.04[e]
Total tetra-octa CDD	ng/g	260	111[e]	170	48[e]	98	120	NM	76[e]	7.0[e]
Total tetra-octa CDF	ng/g	160	64[e]	110	32[e]	43	79	NM	34[e]	< 3

[a] NM = not measured.

[b] Low surrogate recovery for this sample; reported value should be considered an estimate.

[c] Broken probe at end of test; leak check failed; particulate test repeated as Run 5C.

[d] SO_2 results are probably biased high; interference due to stack gas moisture is suspected.

[e] Average of replicate analyses.

The total tetra-octaCDD measured in the ESP fly ash samples ranges from 720 to 2,100 ng/g; the measured total tetra-octaCDF ranges from 270 to 1,600 ng/g. The total tetra-octaCDD measured in the bottom ash samples ranges from 7.0 to 260 ng/g; the measured total tetra-octaCDF ranges from < 3 to 160 ng/g.

SECTION 3.0

INCINERATOR DESCRIPTION AND OPERATION

The City of Philadelphia's municipal incinerators are briefly described in Section 3.1. The operating conditions of the incinerator during the test period are presented in Section 3.2.

3.1 DESCRIPTION OF CITY OF PHILADELPHIA NORTHWEST AND EAST CENTRAL INCINERATORS

The City of Philadelphia northwest incinerator plant operates two refuse furnaces which can each process up to 375 tons of trash per day. The operation of the units is designed to achieve a 90% volume reduction in refuse. Each furnace consists of a single (primary) excess air combustion chamber with air cooled walls. Exhausts from each furnace pass through cooling sprays, two evaporation towers, a two-stage (field) ESP, and the stack. Figure 1 is a schematic of the northwest incinerator furnace.

An elevated crane with a clam-shell bucket lifts the refuse from the storage bin into a charging hopper and water-cooled gravity chute. Refuse drops from the chute onto the inclined traveling grate, which continuously feeds the refuse onto a horizontal traveling grate. Each grate is driven by independent variable speed motors. The total effective grate area provided by the two grates is 480 ft^2 per furnace. Combustion air (taken from outside the building) is provided to each furnace by a 50 hp forced draft fan. The underfire/overfire air ratio is adjusted by dampers in the forced draft ductwork. The refractory lined furnaces are designed to operated at a maximum temperature of 2100°F.

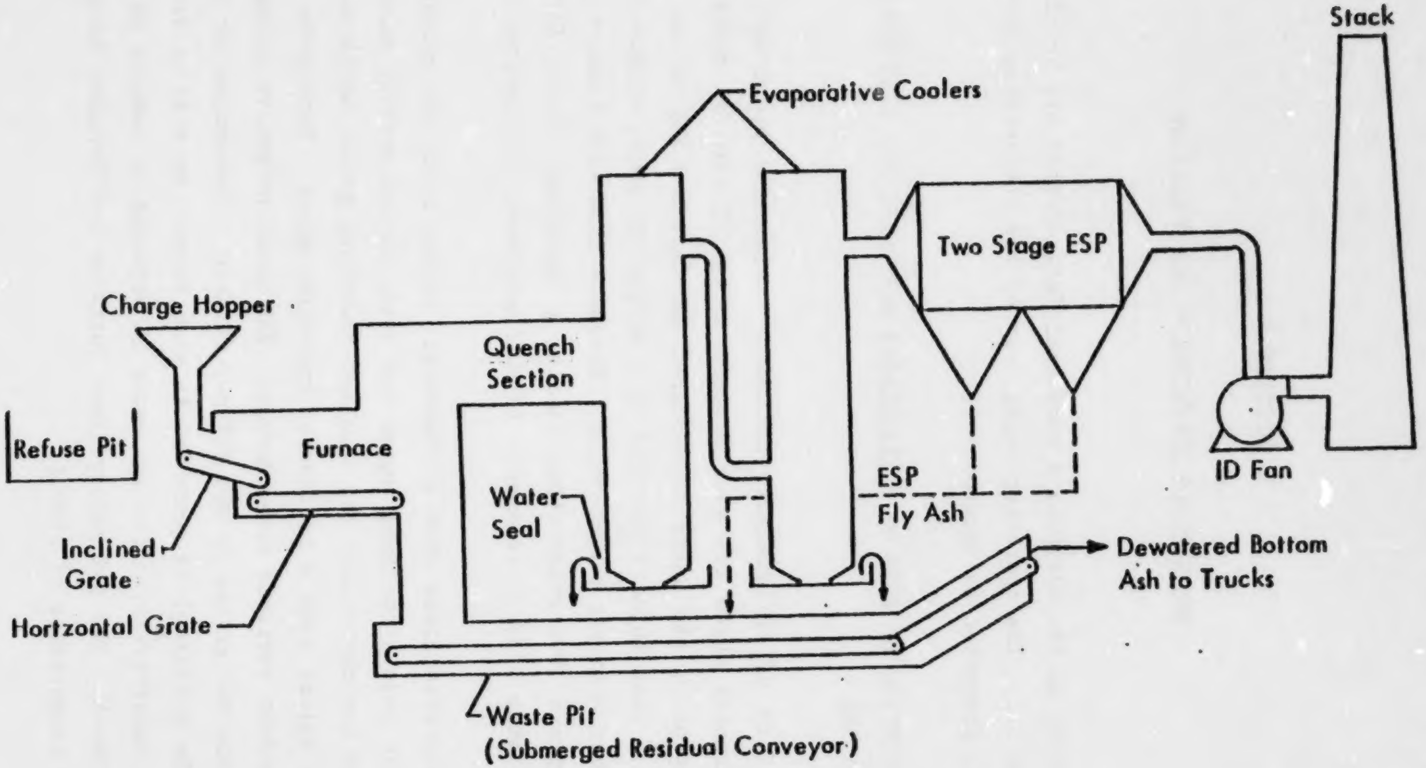

Figure 1. Simplified schematic of Northwest incinerator (Unit 1 or 2)

Incinerator residues drop off the edge of the horizontal grate and fall through a series of residue-quenching sprays and onto a submerged residue conveyor. The ESP fly ash also is discharged onto the submerged residue conveyor. Residue is discharged into trucks.

Furnace flue gases exit the furnaces through spray chambers where air-atomized water cools the gases to the designed ESP operating temperature. The cooling water evaporates in the two evaporation towers so that flue gases entering the ESP are between 550° and 600°F. The cyclonic flow in the towers is also designed to remove the largest particles from the flue gases prior to their entry into the ESP.

Flue gases leave the towers and travel through the precipitator breeching where turning vanes and baffle plates ensure even gas distribution throughout the device. Treated flue gases are drawn from each precipitator by an induced draft variable speed fan and exit the plant through a single stack.

The EC incinerator units are similar in design to the NW incinerator units, with only minor differences.

3.2 INCINERATOR OPERATION

The incinerator and electrostatic precipitator operating conditions during the tests are summarized in Tables 3, 4, and 5 for NW Unit 1, NW Unit 2, and EC Units 1 and 2, respectively.

The purpose of the test primarily was to determine PCDD, PCDF, and particulate emissions from the incinerator during normal operation. Two main criteria were agreed upon by the EPA and the City of Philadelphia as indicating normal operation:

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TABLE 3. SUMMARY OF PROCESS OPERATING DATA, NW UNIT NO. 1

Run Date Time period	4A/B 3/02/85 1130-1716	5A/B 3/03/85 0938-1415	6A/B 3/05/85 1336-1855
Indicated inclined stoker speed, avg. ft/hr	66	60	70
(range)	(61-70)	(60)	(70)
Measured[a] inclined stoker speed, avg. ft/hr	75[b]	74	86
(range)	c	(74)	(86)
Indicated horizontal stoker speed, avg. ft/hr	89	70	80
(range)	(80-95)	(70)	(78-90)
Measured horizontal stoker speed, avg. ft/hr	123	115	140
(range)	(120-128)	(113-115)	(132-160)
Furnace temperature, avg. °F[d]	1910	1770	1760
(range)	(1700-2100)	(1600-2000)	(1550-2000)
Furnace draft, avg. in. H_2O	0.50	0.50	0.40
(range)	(0.50-0.55)	(0.45-0.50)	(0.35-0.45)
Field A, primary voltage, avg. volts	250	240	230
(range)	(230-270)	(230-250)	(210-240)
Field A, primary current, avg. amps	105	105	110
(range)	(90-115)	(90-125)	(105-120)
Field A, secondary current, avg. MA	460	410	420
(range)	(330-480)	(340-490)	(380-480)
Field B, primary voltage, avg. volts	235	250	270
(range)	(185-260)	(250-260)	(270)
Field B, primary current, avg. amps	120	120	100
(range)	(120)	(120)	(95-105)
Field B, secondary current, avg. MA	375	285	235
(range)	(300-415)	(240-410)	(230-240)

---

[a] Visually timed.

[b] At indicated speed of 61.

[c] Only one reading.

[d] Average temperature calculated from 1/2-hr readings recorded during each test; ranges are minimum/maximum values on the chart record for each test period.

TABLE 4. SUMMARY OF PROCESS OPERATING DATA, NW UNIT NO. 2

Run Date Time period	1A/B 2/27/85 1530-2010	2A/B 2/28/85 1200-1717	3A/B 3/01/85 0935-1427	5C 3/03/85 1610-1902
Indicated inclined stoker speed, avg. ft/hr	70	70	71	61
(range)	(70)	(70)	(71)	(61)
Measured[a] inclined stoker speed, avg. ft/hr	b	b	b	73
(range)				(72-73)
Indicated horizontal stoker speed, avg. ft/hr	65	90	93	86
(range)	(65)	(75-100)	(70-100)	(75-105)
Measured horizontal stoker speed, avg. ft/hr	b	b	150	144
(range)			(133-160)	(131-167)
Furnace temperature, avg. °F[c]	1,730	1,740	1,700	1,750
(range)	(1600-2000)	(1550-1900)	(1550-1850)	(1650-1950)
Furnace draft, avg. in. H_2O	0.40	0.40	0.30	0.30
(range)	(0.35-0.50)	(0.35-0.42)	(0.30-0.35)	(0.25-0.35)
Field A, primary voltage, avg. volts	225	215	215	215
(range)	(210-230)	(210-240)	(210-220)	(200-220)
Field A, primary current, avg. amps	80	70	80	85
(range)	(60-90)	(60-90)	(65-100)	(75-95)
Field A, secondary current, avg. MA	245	280	290	285
(range)	(200-280)	(240-300)	(260-310)	(260-300)
Field B, primary voltage, avg. volts	185	180	170	175
(range)	(155-220)	(165-200)	(160-190)	(165-180)
Field B, primary current, avg. amps	100	95	100	100
(range)	(95-100)	(80-110)	(95-100)	(100)
Field B, secondary current, avg. MA	550	550	650	550
(range)	(550)	(550)	(600-700)	(550)

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[a] Visually timed.

[b] Not measured.

[c] Average temperature calculated from 1/2-hr readings recorded during each test; ranges are minimum/maximum values on the chart record for each test period.

TABLE 5. SUMMARY OF PROCESS OPERATING DATA: EC UNIT NOS. 1 AND 2

Run Date Time period	7 3/07/85 1150-1513	8 3/07/85 1646-2012
Unit	1	2
Indicated inclined grate speed, avg. ft/hr (range)	80 (80)	79 (62-83)
Measured inclined grate speed, avg. ft/hr (range)	101 (91-103)	84 (72-98)
Indicated horizontal grate speed, avg. ft/hr (range)	a	a
Measured horizontal grate speed, avg. ft/hr (range)	147 (145-150)	160 (160)
Furnace temperature, avg. °F (range)	1840 (1740-1940)	1890 (1760-2000)
Furnace draft, avg. in. H_2O (range)	0.15[b] (0.1-0.2)	0.20 (0.10-0.20)
Field A, primary voltage, avg. volts (range)	240 (190-280)	230 (220-230)
Field A, primary current, avg. amps (range)	115 (70-175)	145 (145)
Field A, secondary current, avg. MA (range)	390 (300-600)	590 (550-600)
Field B, primary voltage, avg. volts (range)	360 (360-380)	430 (410-450)
Field B, primary current, avg. amps (range)	170 (150-190)	195 (180-200)
Field B, secondary current, avg. MA (range)	720 (670-790)	840 (790-880)

[a] No working indicator.

[b] Gauge at furnace, not at control panel.

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1. Furnace temperature between 1400° and 1800°F; and

2. An indicated inclined grate speed of 70 ft/hr.

The Inclined grate speed is used as the indicator of feedrate to the incinerator. Another indicator of feedrate is the number of charges (crane loads) per hour to the charge hopper. Previous tests at these facilities indicate 20 charges per hour is normal. Both these parameters were monitored during the emission testing in order to verify that the facilities were operating normally. Actual measurements of the weight of refuse being charged to the incinerator were not taken.

With the exception of run 4 on NW Unit 1, the furnace temperature during the tests averaged between 1600° to 1800°F. Occasional excursions above 1800°F to as high as 2100°F were noted. The furnace high temperature warning is at 2100°F.

The indicated inclined stoker speeds ranged from 60 (one test) to 70 ft/hr at the NW Units 1 and 2. During the tests, the indicated inclined stoker speeds for both East Central units was 80 ft/hr. During the testing a discrepancy between the indicated grate speeds and the observed (measured) grate speeds was noted. Therefore, the grate speeds were occasionally measured by timing the number of grate sections passing a fixed point. Table 6 summarizes the comparison of the measured and indicated grate speeds for each unit; speeds for both the inclined and the horizontal grates are presented.

Table 7 summarizes the observed charging rate (crane loads/hr) of refuse to the feed hopper. Hourly readings of observed charging rates ranged from 12 to 24 charges per hour, and averaged 18.5 charges per hour.

TABLE 6. SUMMARY OF INDICATED VERSUS MEASURED GRATE SPEEDS (ft/hr)

	NW Unit 1		NW Unit 2		EC Unit 1		EC Unit 2	
	Indicated	Measured[a]	Indicated	Measured[a]	Indicated	Measured[a]	Indicated	Measured[a]
Inclined grate:	60	74	61	73	80	101	62	72
	70	86	70	84			71	84
							83	98
Correction factor[b]	1.2		1.2		1.3		1.2	
Horizontal grate:	70	114	80	132	No indicating meter or chart		No indicating meter or chart	
	80	130	105	167				
	95	140						
Correction factor[b]	1.6		1.6					

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[a] Average of all measurements taken at listed indicated speed.

[b] Actual (measured) speed = indicated speed x correction factor.

TABLE 7. REFUSE CHARGE RATE TO FEED HOPPER

Run	Facility	Date	Begin time	End time	Observed charges (charges/hr)
1AB	NW No. 2	2/27/85	1545	1645	17
			1645	1730	12/45 min
			1820	1920	20
			1920	2000	11/40 min
2AB	NW No. 2	2/28/85	1200	1300	20
			1300	1400	18
			1400	1500	17
			1500	1600	21
			1600	1700	18
			1700	1715	3
3AB	NW No. 2	3/01/85	0930	1030	18
			1030	1130	20
			1130	1230	18
			1230	1330	18
			1330	1430	17
4AB	NW No. 1	3/02/85	1115	1215	24
			1215	1315	24
			1315	1415	15
			1415	1515	19
			1515	1615	18
			1615	1715	18
5AB	NW No. 1	3/03/85	0940	1040	12
			1040	1140	21
			1140	1240	16
			1240	1340	18
			1340	1410	9/30 min
5C	NW No. 2	3/03/85	1610	1710	18
			1710	1810	21
			1810	1901	15/50 min
6	NW No. 1	3/05/85	1348	1448	22
			1448	1548	21
			1655	1755	23
			1755	1855	17
7	EC No. 1	3/07/85	1206	1306	19
			1306	1406	19
			1406	1506	19
8	EC No. 2	3/07/85	1707	1807	17
			1807	1907	13
			1907	2007	12

SECTION 4.0

RESULTS AND DISCUSSION OF RESULTS

4.1 POLYCHLORINATED DIBENZO-p-DIOXINS (PCDDs) AND POLYCHLORINATED DIBENZOFURANS (PCDFs)

4.1.1 Stack Gas Emissions

Tables 8 and 9 present the PCDD and PCDF results of the stack emissions measurements from NW Units 1 and 2, respectively. Low surrogate recoveries were obtained during analysis of Run 6A. Although the results are reported, the results should be considered an estimate. The particulate sample taken simultaneously, Run 6B, currently is being analyzed for PCDDs and PCDFs. The results of this analysis will be reported as an addendum to this report. Results for the field blank sampling train also are reported in Table 9; no blank problems were identified.

Tables 10 and 11 present the 2,3,7,8-substituted tetra-octa isomers of dibenzodioxin and dibenzofuran measured in the stack gas emissions from NW Units 1 and 2, respectively. These results were obtained by identifying the chromatogram peaks for the specific isomers of interest by their relative retention times. Results for the specific isomer were then calculated using the response factor for the homolog group, in general; the response factors for each homolog group were calculated from the calibration standard. A more detailed explanation of the analyses and calculations conducted is presented in Section 5.

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TABLE 8. SUMMARY OF TOTAL TETRA-OCTA DIBENZO-p-DIOXIN AND DIBENZOFURAN EMISSIONS, NW UNIT NO. 1

Run No.	4A			5A			6A[a]			6B		
Date	3/02/85			3/03/85			3/05/85			3/05/85		
Start time	1130			0940			1340			1342		
End time	1710			1410			1850			1852		
Sample time, min	240			240			240			240		
Sample volume, Nm^3 (dscf)	2.607 (92.065)			2.486 (87.803)			2.543 (89.798)			2.466 (87.074)		
Stack volumetric flow rate, Nm^3/min (dscfm)	2,131 (75,262)			2,221 (78,450)			2,106 (74,389)			2,103 (74,262)		
Stack gas velocity, m/min (ft/sec)	1,551 (84.8)			1,509 (82.5)			1,527 (83.5)			1,529 (82.6)		
Stack gas temp., °C (°F)	268 (514)			267 (513)			265 (508)			268 (515)		
Stack gas moisture, % vol.	26.9			22.9			26.7			26.4		
Oxygen concentration, %	14.4			15.1			14.2			14.2		
Carbon dioxide concentration, %	5.7			5.1			5.7			5.7		
Percent isokinetic	106			97			104			103		
	ng	ng/Nm^3	ng/sec	ng	ng/Nm^3	ng/sec	ng	ng/Nm^3	ng/sec	ng	ng/Nm^3	ng/sec
2,3,7,8-TCDD	14	5.4	190	11	4.4	160	21	8.3	290	18	7.3	260
TCDD	510	190	6,900	370	150	5,500	400	160	5,500	1,300	530	19,000
P_5CDD	1,600	610	22,000	1,100	440	16,000	910	360	13,000	2,600	1,100	39,000
HxCDD	810	310	11,000	860	350	13,000	7,300	3,000	100,000	1,600	650	~~2,300~~ 23,000
HpCDD	320	120	4,400	370	150	5,500	2,500	930	34,000	670	270	9,500
OCDD	160	61	2,200	130	52	1,900	950	370	13,000	260	100	3,500
Total Tetra-Octa CDD	3,400	1,300	46,000	2,800	1,100	42,000	12,000	4,700	170,000	6,400	2,600	91,000
2,3,7,8-TCDF	70	27	950	36	14	540	88	35	1,200	81	33	1,200
TCDF	1,400	540	19,000	900	360	13,000	1,400	550	19,000	2,600	1,100	39,000
P_5CDF	1,700	650	23,000	1,000	402	15,000	1,400	550	19,000	4,800	1,900	67,000
HxCDF	800	310	11,000	800	320	12,000	7,900	3,100	110,000	2,900	1,200	42,000
HpCDF	260	100	3,500	290	120	4,300	1,900	750	26,000	660	270	9,500
OCDF	26	10	350	25	10	370	110	43	1,500	57	23	800
Total Tetra-Octa CDF	4,200	1,600	57,000	3,000	1,200	45,000	13,000	5,000	180,000	11,000	4,500	160,000

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[a] Low surrogate recovery on this sample.

TABLE 9. SUMMARY OF TOTAL TETRA-OCTA DIBENZO-p-DIOXIN AND DIBENZOFURAN EMISSIONS, NW UNIT NO. 2

Run No.	1A			2A			3B			Blank		
Date	2/27/85			2/28/85			3/01/85			3/04/85		
Start time	1549			1200			0941			NA[a]		
End time	1956			1712			1427			NA		
Sample time, min	192			240			240			NA		
Sample volume, Nm^3 (dscf)	2.059 (72.710)			2.785 (98.342)			2.573 (90.854)			NA		
Stack volumetric flow rate, Nm^3/min (dscfm)	2,378 (83,985)			2,488 (87,859)			2,360 (83,327)			NA		
Stack gas velocity, m/min (ft/sec)	1,704 (93.2)			1,658 (90.7)			1,575 (86.1)			NA		
Stack gas temp., °C (°F)	281 (538)			275 (528)			268 (514)			NA		
Stack gas moisture, % vol.	24.8			21.3			22.1			NA		
Oxygen concentration, %	15.9			15.5			15.4			NA		
Carbon dioxide concentration	4.2			4.7			4.6			NA		
Percent isokinetic	94.4			97.7			97.3			NA		
	ng	ng/Nm^3	ng/sec	ng	ng/Nm^3	ng/sec	ng	ng/Nm^3	ng/sec	ng	ng/Nm^3	ng/sec
2,3,7,8-TCDD	7.1	3.4	140	19	6.8	280	11	4.3	170	0.073[b]	NA	NA
TCDD	230	110	4,400	600	220	8,990	260	100	4,000	0.073[b]	NA	NA
P_5CDD	540	260	10,000	1,700	610	25,000	900	350	14,000	ND (0.044)	NA	NA
HxCDD	940	460	18,000	780	280	12,000	880	340	13,000	ND (0.038)	NA	NA
HpCDD	340	170	6,500	360	130	5,400	430	170	6,600	ND (0.005)	NA	NA
OCDD	130	63	2,500	160	57	2,400	190	74	2,900	ND (0.010)	NA	NA
Total Tetra-Octa CDD	2,200	~~1,000~~ 1,100	42,000	3,600	1,300	54,000	2,700	1,000	41,000	< 0.17	NA	NA
2,3,7,8-TCDF	18	8.7	350	51	18	760	34	13	520	0.012[b]	NA	NA
TCDF	360	170	6,900	1,200	430	18,000	700	272	11,000	0.012[b]	NA	NA
P_5CDF	520	250	10,000	1,600	570	24,000	1,000	390	15,000	ND (0.022)	NA	NA
HxCDF	930	450	18,000	580	210	8,600	710	280	11,000	ND (0.005)	NA	NA
HpCDF	310	150	6,000	210	75	3,100	220	86	3,400	ND (0.005)	NA	NA
OCDF	30	15	580	32	11	480	28	11	430	ND (0.0023)	NA	NA
Total Tetra-Octa CDF	2,200	1,000	42,000	3,600	1,300	54,000	2,700	1,000	41,000	< 0.047		

[a] NA = not applicable.

[b] Carry over from previous standard injection.

TABLE 10. SUMMARY OF EMISSIONS OF 2,3,7,8-SUBSTITUTED DIBENZO-p-DIOXIN AND DIBENZOFURAN ISOMERS, NW UNIT NO. 1

Run No.	4A			5A			6A[a]			6B		
Date	3/02/85			3/03/85			3/05/85			3/05/85		
Start time	1130			0940			1340			1342		
End time	1710			1410			1850			1852		
Sample time, min	240			240			240			240		
Sample volume, Nm³ (dscf)	2.607 (92.065)			2.486 (87.803)			2.543 (89.798)			2.466 (87.074)		
Stack volumetric flow rate, Nm³/min (dscfm)	2,131 (75,262)			2,221 (78,450)			2,106 (74,389)			2,103 (74,262)		
Stack gas velocity, m/min (ft/sec)	1,551 (84.8)			1,509 (82.5)			1,527 (83.5)			1,529 (82.6)		
Stack gas temp., °C (°F)	268 (514)			267 (513)			265 (508)			268 (515)		
Stack gas moisture, % vol.	26.9			22.9			26.7			26.4		
Oxygen concentration, %	14.4			15.1			14.2			14.2		
Carbon dioxide concentration, %	5.7			5.1			5.7			5.7		
Percent isokinetic	106			97			104			103		
	ng	ng/Nm³	ng/sec	ng	ng/Nm³	ng/sec	ng	ng/Nm³	ng/sec	ng	ng/Nm³	ng/sec
2,3,7,8-TCDD	14	5.4	190	11	4.4	~~164~~ 160	21	8.3	290	18	7.3	260
1,2,3,7,8-PCDD	130	50	1,800	85	34	1,270	61	24	842	b	b	b
1,2,3,4,7,8-HxCDD	100	38	1,400	98[c]	39	1,500	810	320	11,000	180	73	2,600
1,2,3,4,6,7,8-HpCDD	160	61	2,200	190[c]	76	2,800	1,200	470	17,000	310	130	4,600
OCDD	160	61	2,200	130[c]	52	1,900	950	370	13,000	260	100	3,500
2,3,7,8-TCDF	70	27	950	36	14	540	88	35	1,200	81	33	1,200
1,2,3,7,8/1,2,3,4,8-PCDF	160	61	2,200	100	40	1,500	140	55	1,900	b	b	b
2,3,4,7,8-PCDF	198	76	2,700	130	52	1,900	630	250	8,700	b	b	b
1,2,3,4,7,8-HxCDF	130	50	1,800	97[c]	39	1,400	760	300	10,000	500	200	7,000
1,2,3,6,7,8-HxCDF	160	61	2,200	190[c]	76	2,800	2,100	830	29,000	320	130	4,600
1,2,3,4,6,7,8-HpCDF	190	73	2,600	220[c]	88	3,300	1,480	580	20,000	570	230	8,100
1,2,3,4,7,8,9-HpCDF	18	6.9	245	17[c]	6.8	250	97	38	1,300	26	11	380
OCDF	26	10	350	25	10	370	110	43	1,500	57	23	810

[a] Low surrogate recovery on this sample; results should be considered an estimate.

[b] Unable to resolve PCDD/PCDF specific analytes.

[c] Only first replicate reported.

TABLE 11. SUMMARY OF EMISSIONS OF 2,3,7,8-SUBSTITUTED DIBENZO-p-DIOXIN AND DIBENZOFURAN ISOMERS, NW UNIT NO. 2

Run No.	1A			2A			3B		
Date	2/27/85			2/28/85			3/01/85		
Start time	1549			1200			0941		
End time	1956			1712			1427		
Sample time, min	192			240			240		
Sample volume, Nm³ (dscf)	2.059 (72.710)			2.785 (98.342)			2.573 (90.854)		
Stack volumetric flow rate, Nm³/min (dscfm)	2,378 (83,985)			2,488 (87,859)			2,360 (83,327)		
Stack gas velocity, m/min (ft/sec)	1,704 (93.2)			1,658 (90.7)			1,575 (86.1)		
Stack gas temp., °C (°F)	281 (538)			275 (528)			268 (514)		
Stack gas moisture, % vol.	24.8			21.3			22.1		
Oxygen concentration, %	15.9			15.5			15.4		
Carbon dioxide concentration, %	4.2			4.7			4.6		
Percent isokinetic	94.4			97.7			97.3		
	ng	ng/Nm³	ng/sec	ng	ng/Nm³	ng/sec	ng	ng/Nm³	ng/sec
2,3,7,8-TCDD	7.1 ~~24~~	3.4 ~~12~~	140 ~~460~~	19	6.8	280	11	4.3	170
1,2,3,7,8-PCDD	55	27	1,100	150	54	2,200	69	27	1,100
1,2,3,4,7,8-HxCDD	130	63	2,500	91	33	1,400	100	39	1,500
1,2,3,4,6,7,8-HpCDD	170	83	3,300	190	68	2,800	220	86	3,400
OCDD	130	63	2,500	160	57	2,400	190	74	2,900
2,3,7,8-TCDF	18	8.7	350	51	18	760	36	14	550
1,2,3,7,8/1,2,3,4,8-PCDF	20	10	390	160	57	2,400	a	a	a
2,3,4,7,8-PCDF	27	13	520	160	57	2,400	140	54	2,100
1,2,3,4,7,8-HxCDF	130	63	2,500	110	39	1,600	78	30	1,200
1,2,3,6,7,8-HxCDF	130	63	250	110	39	1,600	170	66	2,600
1,2,3,4,6,7,8-HpCDF	230	110	4,400	150	54	2,200	150	58	2,300
1,2,3,4,7,8,9-HpCDF	18	8.7	350	17	6.1	250	17	6.6	260
OCDF	30	15	580	32	11	480	28	11	430

[a] Not discernible from other isomers present.

With the exception of the low surrogate recoveries for Run 6A, no serious anomalies in sampling or analysis were noted for the measurement of PCDDs and PCDFs in the stack gas emissions.

4.1.2 ESP Fly Ash Samples

Tables 12 and 13 report the PCDD and PCDF concentrations measured in the ESP fly ash samples from the NW and EC facilities, respectively. Where applicable, results are reported for replicate analyses and/or multiple GC/MS injections. Results for replicate sample analyses (i.e., extraction and analysis of multiple aliquots of the sample) are reported as Replicate 1, Replicate 2, etc. Multiple analyses of the same aliquot (i.e., same sample extract) are reported as Replicate 1A, 1B, etc. Note that, in some cases (e.g., Table 12, Run 1A/B, Replicate 2B), replicate analyses are reported for only some homologs. This situation occurs because multiple GC/MS injections are required to quantitate the five PCDD and PCDF homologs; in some cases, all the injections required to quantitate all homologs were not replicated.

The only anomaly related to the sampling and analysis of fly ash samples noted during the study, was that samples from runs 1 and 5 contained considerable amounts of charred paper flakes. This resulted in composites of a fairly nonhomogeneous nature.

4.1.3 Bottom Ash Samples

Tables 14 and 15 report the PCDD and PCDF concentrations measured in the bottom ash samples taken from the NW and EC facilities, respectively. Note that the bottom ash samples were often nonhomogeneous; relatively large pieces of inert materials (e.g., pebbles) and unburned refuse (e.g., metal) often were contained in the ash samples. Large objects such as pebbles and pieces of metal were removed from the sample aliquot prior to extraction by sieving. The calculated concentration (ng/g) is based on the final weight of the sample fraction after sieving. The final sieved fraction which was extracted ranged from 26 to 73% of the original aliquot weight. More detail of the procedure used to prepare the bottom ash samples for analysis is presented in Section 5.

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TABLE 12. SUMMARY OF TOTAL TETRA-OCTA DIBENZO-p-DIOXIN AND DIBENZO FURAN CONCENTRATION IN FLY ASH, NW UNIT NOS. 1 AND 2 (ng/g)

	NW Unit 1				NW Unit 2					
Run No.	4 A/B	5 A/B		6 A/B	1 A/B			2 A/B	3 A/B	
Date	3/02/85	3/03/85		3/05/85	2/27/85			2/28/85	3/01/85	
Start time[a]	1142	0950		1352	1553			1215	0945	
End time[b]	1700	1420		1833	2000			1725	1435	
		Rep. 1	Rep. 2		Rep. 1	Rep. 2A	Rep. 2B[d]		Rep. 1A	Rep. 1B
2,3,7,8-TCDD	6.6	5.9	6.4	3.9	6.0	4.0	4.9	3.7	c	4.0
TCDD	340	330	410	290	270	160	230	160	c	170
PCDD	640	730	800	450	660	330	450	380	c	280
HxCDD	660	1,000	510	750	350	790	NA[e]	390	420	280
HpCDD	170	240	120	290	110	230	NA	95	100	96
OCDD	42	49	28	49	31	55	NA	20	24	21
Total Tetra-Octa CDD	1,900	2,300	1,900	1,800	1,400	1,600	-	1,000	-	850
2,3,7,8-TCDF	13	11	11	6.8	11	7.1	8.0	6.3	c	9.0
TCDF	330	300	350	210	280	170	200	170	c	300
PCDF	370	430	520	270	410	240	220	260	c	440
HxCDF	500	920	570	900	350	640	NA	390	490	490
HpCDF	112	210	110	170	100	150	NA	72	110	87
OCDF	6.2	11	6.8	7.7	6.2	8.6	NA	1.8	5.3	5.1
Total Tetra-Octa CDF	1,300	1,900	1,200	1,600	1,100	1,200	-	900	-	1,300

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[a] Time when first grab sample was taken.

[b] Time when last grab sample was taken.

[c] Not analyzed for during first injection.

[d] Replicates 1 and 2 indicate replicate extraction/analysis of sample; letter suffix (i.e., A, B) indicates duplicate analysis of same sample extract.

[e] NA = not analyzed.

TABLE 13. SUMMARY OF TOTAL TETRA-OCTA DIBENZO-p-DIOXIN AND DIBENZOFURAN CONCENTRATION IN FLY ASH, EC UNIT NOS. 1 AND 2 (ng/g)

	EC Unit 1		EC Unit 2				Bottle blank	Method blank	Method blank
Run No.	7		8						
Date	3/07/85		3/17/85				-	-	-
Start time[a]	1159		1700				-	-	-
End time[b]	1502		2005				-	-	-
	Rep. 1	Rep. 2	Rep. 1	Rep. 2	Rep. 3A	Rep. 3B[c]			
2,3,7,8-TCDD	3.5	2.5	0.60	0.62	0.48	0.56	ND[d] (0.025)	ND (0.020)	ND (0.020)
TCDD	210	170	46	44	35	44	ND (0.025)	ND (0.020)	ND (0.020)
PCDD	730	610	230	210	140	160	ND (0.037)	ND (0.020)	ND (0.020)
HxCDD	530	680	150	170	140	NA[e]	ND (0.020)	ND (0.020)	ND (0.020)
HpCDD	270	270	133	140	150	NA	ND (0.037)	ND (0.020)	ND (0.020)
OCDD	170	140	190	190	180	NA	ND (0.025)	ND (0.025)	ND (0.025)
Total Tetra-Octa CDD	1,900	1,900	750	750	650	-	ND < 0.1	ND < 0.1	ND < 0.1
2,3,7,8-TCDF	6.4	5.7	1.4	1.5	1.2	1.4	0.03	ND (0.020)	ND (0.020)
TCDF	180	150	34	39	28	31	0.03	ND (0.020)	ND (0.020)
PCDF	270	250	64	81	46	54	ND (0.020)	ND (0.020)	ND (0.020)
HxCDF	330	350	71	73	62	NA	ND (0.025)	ND (0.020)	ND (0.020)
HpCDF	160	150	76	98	62	NA	ND (0.037)	ND (0.020)	ND (0.020)
OCDF	24	19	23	23	20	NA	ND (0.037)	ND (0.020)	ND (0.020)
Total Tetra-Octa CDF	960	920	270	310	220	-	< 0.75	ND < 0.1	ND < 0.1

[a] Time when first grab sample was taken.

[b] Time when last grab sample was taken.

[c] Replicates 1 and 2 indicate replicate extraction/analysis of sample; letter suffix (i.e., A, B) indicates duplicate analysis of same sample extract.

[d] ND = Not detected; detection limit stated in parenthesis.

[e] NA = not analyzed.

TABLE 14. SUMMARY OF TOTAL TETRA-OCTA DIBENZO-p-DIOXIN AND DIBENZO FURAN CONCENTRATION IN BOTTOM ASH, NW UNIT NOS. 1 AND 2 (ng/g)

	NW Unit 1					NW Unit 2				
Run No.	4 A/B		5 A/B		6 A/B	1 A/B			2 A/B	3 A/B
Date	3/02/85		3/03/85		3/05/85	2/27/85			2/28/85	3/01/85
Start time[a]	1145		0955		1357	1600			1210	0950
End time[b]	1705		1425		1831	2003			1720	1440
	Rep. 1A	Rep. 1B	Rep. 1	Rep. 2		Rep. 1A	Rep. 1B	Rep. 2		
2,3,7,8-TCDD	1.5	NA[c]	0.77	0.41	0.92	0.47	NA	0.21	0.79	0.83
TCDD	47	NA	33	16	26	12	NA	7.0	23	25
PCDD	92	NA	71	25	52	32	NA	14	42	42
HxCDD	69	50	35	12	33	13	11	6.5	18	30
HpCDD	31	20	11	4.8	18	4.2	3.9	2.6	9.1	12
OCDD	21	17	5.9	2.9	37	2.9	2.9	1.8	5.7	9.7
Total Tetra-Octa CDD	260	-	160	61	170	64	-	32	98	120
2,3,7,8-TCDF	2.7	NA	1.1	0.69	1.5	0.74	NA	0.38	0.86	1.4
TCDF	47	NA	25	13	29	13	NA	8.2	18	24
PCDF	49	NA	29	16	26	14	NA	7.2	18	25
HxCDF	48	37	24	8.1	30	12	9.1	4.5	0.84	22.1
HpCDF	15	11	7.8	2.6	18	2.2	2.8	1.4	5.3	6.6
OCDF	1.9	1.9	0.95	0.40	4.2	0.22	0.27	0.20	0.75	1.0
Total Tetra-Octa CDF	160	-	87	40	110	41	-	22	43	79

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[a] Time when first grab sample was taken.

[b] Time when last grab sample was taken.

[c] NA = not analyzed.

TABLE 15. SUMMARY OF TOTAL TETRA-OCTA DIBENZO-p-DIOXIN AND DIBENZOFURAN CONCENTRATION IN BOTTOM ASH, EC UNIT NOS. 1 AND 2 (ng/g)

	EC Unit 1		EC Unit 2			Bottle blank	Method blank	Method blank
Run No.	7		8					
Date	3/07/85		3/07/85			-	-	-
Start time[a]	1156		1710			-	-	-
End time[b]	1508		2009			-	-	-
	Rep. 1	Rep. 2	Rep. 1	Rep. 2	Rep. 3			
2,3,7,8-TCDD	0.18	0.17	ND (0.045)	0.016	0.031	ND (0.014)	ND (0.010)	ND (0.010)
TCDD	6.7	7.1	0.14	0.20	0.16	ND (0.030)	ND (0.010)	ND (0.010)
PCDD	16	23	0.67	1.2	0.70	ND (0.018)	ND (0.010)	ND (0.015)
HxCDD	18	25	0.76	1.0	1.9	ND (0.069)	ND (0.026)	ND (0.030)
HpCDD	10	15	1.3	1.3	1.9	0.090	ND (0.010)	ND (0.010)
OCDD	13	17	3.2	3.2	3.4	0.14	ND (0.014)	ND (0.010)
Total Tetra-Octa CDD	64	87	6.1	6.9	8.1	< 0.36	ND (< 0.08)	ND (< 0.09)
2,3,7,8-TCDF	0.25	0.32	0.041	0.029	0.041	ND (0.014)	ND (0.010)	ND (0.010)
TCDF	5.0	7.6	0.55	0.70	0.38	ND (0.014)	ND (0.010)	ND (0.010)
PCDF	7.1	11	0.24	0.82	0.76	ND (0.030)	ND (0.010)	ND (0.010)
HxCDF	10	9.1	0.39	0.52	0.77	ND (0.022)	ND (0.045)	ND (0.017)
HpCDF	6.0	7.6	0.35	0.57	0.70	0.11	ND (0.023)	ND (0.022)
OCDF	1.7	2.0	ND (0.24)	ND (0.29)	ND (0.39)	0.18	ND (0.015)	ND (0.010)
Total Tetra-Octa CDF	30	37	< 1.8	< 2.9	< 3.0	< 0.37	ND (< 0.10)	ND (< 0.08)

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[a] Time when first grab sample was taken.

[b] Time when last grab sample was taken.

4.2 PARTICULATE MATTER AND HYDROGEN CHLORIDE EMISSIONS

Table 16 presents the results of the particulate matter and HCl stack emissions measurements from NW Units 1 and 2. Run 3A failed the final leak check because of a broken probe liner. The results of this test run are reported, although the run technically is invalid. An additional particulate test run (5C) on NW Unit 2 was conducted to obtain three valid tests.

The particulate matter results from Run 1B on Unit No. 2 are significantly higher (an order of magnitude) than for the other five test runs. The measurements and calculations for this test were rechecked and found to be valid. Visual examination of the filter during reweighing revealed a wax-like substance on the filter.

The results of blank analyses for particulate matter and HCl are reported with the Quality Assurance Results, Section 4.5.1, Table 20; no problems with sample blanks were identified.

4.3 CONTINUOUS EMISSION MONITORING

Table 17 presents a summary of all continuous emission monitoring results. The results are reported as the average concentration for the test period; the range of concentrations measured during the test run also is reported.

An NDIR analyzer was used to monitor the SO_2 emissions. When using an NDIR, moisture can interfere with the measurement of pollutants at low levels. Consequently, the SO_2 measurements are suspect and are likely biased high. Moisture interference is not a major concern with the CO_2 measurements because of the high level of CO_2 in the stack gas (i.e., percent instead of ppm). To assure no interference from water or carbon dioxide during the CO measurements, an ascarite scrubber was used prior to the CO monitor.

TABLE 16. SUMMARY OF PARTICULATE AND HCl EMISSIONS

	MW Unit No. 1			MW Unit No. 2			
Run No.	4B	5B	6B	1B	2B	3A[a]	5C
Date	3/02/85	3/03/85	3/05/85	2/27/85	2/28/85	3/01/85	3/03/85
Start time	1132	0942	1342	1547	1212	0935	1610
End time	1712	1412	1852	2006	1710	1425	1902
Sample time, min	240	240	240	192	240	240	144
Sample volume, Nm³ (dscf)	2.562 (90.481)	2.475 (87.415)	2.466 (87.074)	2.042 (72.106)	2.739 (96.714)	2.746 (96.964)	1.566 (55.309)
Stack volumetric flow rate, Nm³/min (dscfm)	2,190 (77,351)	2,267 (80,074)	2,103 (74,262)	2,414 (85,256)	2,512 (88,724)	2,359 (83,292)	2,207 (77,925)
Stack gas velocity, m/min (ft/sec)	1,563 (85.5)	1,537 (84.1)	1,529 (82.6)	1,675 (91.6)	1,654 (90.5)	1,558 (85.2)	1,509 (82.5)
Stack gas temp., °F (°C)	265 (508)	269 (517)	268 (515)	270 (518)	267 (512)	270 (518)	262 (503)
Stack gas moisture, % vol	25.8	22.5	26.4	23.9	20.6	20.9	25.1
Oxygen concentration, %	14.4	15.1	14.2	15.9	15.4	15.5	14.8
Carbon dioxide conc., %	5.7	5.1	5.7	4.2	4.7	4.7	5.3
Percent isokinetic	103	96	103	94	96	101	103
Particulate weight, g[b]	0.3720	0.2665	0.2420	2.4682	0.3505	0.4606	0.1571
Particulate conc., g/Nm³ (gr/dscf)	0.1452 (0.0633)	0.1077 (0.0469)	0.0981 (0.0428)	1.2089 (0.5271)	0.1279 (0.0558)	0.1677 (0.0731)	0.1003 (0.0438)
Corrected particulate conc. at 12% CO_2, g/Nm³ (gr/dscf)[e]	0.31 (0.13)	0.25 (0.11)	0.21 (0.09)	3.5 (1.5)	0.33 (0.14)	0.43 (0.19)	0.23 (0.10)
Particulate emission rate kg/hr (lb/hr)	19 (42)	15 (32)	12 (27)	175 (385)	19 (42)	24 (52)	13 (29)
HCl amount detected, mg[b,c,d]	626	359	607	98.5	198	482	f
HCl concentration, mg/Nm³	244	145	246	48	72	175	f
HCl emission rate, kg/hr	32	20	31	7.0	11	25	f

[a] Probe liner broken; final leak check failed.

[b] Blank corrected.

[c] As HCl.

[d] HCl detected in blank train = 0.4 mg.

[e] Correction calculated using CO_2 obtained by RM3 (integrated bag/Orsat); not CEMS data.

[f] Particulate matter test only.

TABLE 17. SUMMARY OF CONTINUOUS EMISSION MONITORING RESULTS

Facility	NW Unit No. 1			NW Unit No. 2			EC 1	EC 2
Run no.	4A/B	5A/B	6A/B	1A/B	2A/B	3A/B	7	8
Date	3/02/85	3/03/85	3/15/85	2/27/85	2/28/85	3/01/85	3/07/85	3/07/85
Time periods Monitored[a]	1130-1201 1206-1337 1420-1430 1520-1712	0940-1142 1210-1412	1340-1353 1403-1552 1650-1852	1545-1723 1824-2006	1200-1215 1230-1255 1302-1434 1510-1712	0935-1141 1225-1427	1150-1516	1646-2012
Average O_2, %	13.4	14.7	13.6	14.4	15.1	14.9	15.3	16.6
(range)	(11.4-15.0)	(12.7-16.6)	(12.2-15.8)	(12.8-15.9)	(13.7-16.7)	(13.2-16.3)	(14.4-17)	(15.9-17.5)
Average CO_2, %	5.5	4.8	5.6	5.2	4.4	4.5	4.2	3.3
(range)	(3.6-7.6)	(3.0-6.8)	(3.4-6.9)	(3.8-6.7)	(3.0-5.7)	(3.0-6.0)	(3.0-5.5)	(2.3-4.8)
Average CO, ppm	238	240	204	150	193	202	57	16
(range)	(95-1,230)	(95-496)	(119-468)	(69-388)	(123-342)	(127-334)	(17-222)	(4-78)
Average THC, ppm	3	2	7	6	5	< 1	< 1	1
(range)	(2-15)	(0-24)	(2-46)	(0-12)	(4.6-6.8)	(0-6)	(0-6)	(0.4-1.4)
Average SO_2,[b] ppm	203	156	173	122	167	152	40	26
(range)	(160-280)	(126-234)	(134-239)	(91-187)	(146-212)	(88-197)	(16-231)	(10-185)
Average NO_x, ppm	84	78	96	93	79	81	62	48
(range)	(56-104)	(52-106)	(78-111)	(66-111)	(60-96)	(62-114)	(40-83)	(39-57)

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[a] Monitor data logger was stopped when sample trains were stopped; therefore, monitored time period coincides with actual MM5 sampling; strip charts were operated continuously.

[b] SO_2 results are probably biased high; interference due to stack gas moisture is suspected.

The data were recorded on a data logger; measurements recorded every 3 sec were used to calculate 1-min averages. A continuous strip chart record also was obtained. The data logger printouts (1-min averages) and the strip charts are included as Appendix G of this report. Calibration results for the monitors also are reported in Appendix G.

4.4 OPACITY

Tables 18 and 19 present results of visual readings of the opacity of emissions recorded during each test run. The data are tabulated as 6-min averages (Table 18) and total minutes observed at each opacity level (Table 19). The visual emission readings were taken and recorded by EPA observers.

4.5 QUALITY ASSURANCE

The Quality Assurance (QA) program for this project was extensive. The QA program included analyzing blank samples, spiked samples, control samples, and blind audit samples. All samples were spiked with internal standards and surrogates. Duplicate analyses were conducted to assess precision. Depending upon the type of sample, accuracy was assessed by several different means including: (a) analysis of audit samples; (b) analysis of spiked blanks; and (c) surrogate recovery. In addition, several of the samples were analyzed by a second laboratory.

This section is divided into two subsections; Section 4.5.1 summarizes the QA results of MRI's laboratory; and Section 4.5.2 summarizes the results of the second laboratory, Triangle Laboratories, Inc.. All results obtained by MRI in regards to Quality Assurance are reported along with the analytical results for the samples in Appendix C--Laboratory Report: Dioxins. Appendix L provides the complete report of results from Triangle Laboratories, Inc.

TABLE 18. SUMMARY OF OPACITY OBSERVATIONS: 6-MIN AVERAGE OPACITY

Facility	NW Unit No. 1			NW Unit No. 2					EC 1	EC 2
Run No.[a]	4A/B	5A/B	6A/B	1A/B	2A/B	2A/B	3A/B	5C	7	8
Date	3/02/85	3/03/85	3/05/85	2/27/85	2/28/85	2/28/85	3/01/85	3/03/85	3/07/85	3/07/85
Observation begin time	1222	1030	1407	1545	1324	1609	1038	1631	1225	1700
Observation end time	1321	1129	1506	1644	1423	1708	1137	1730	1324	1744
6-Min[b] observation period	Average percent opacity									
0-6	4.8	26.0	2.9	30.6	13.5	12.1	10.6	5.6	0.8	7.7
6-12	7.3	30.4	2.1	17.3	22.1	15.8	12.3	2.9	3.3	2.3
12-18	6.9	27.3	7.1	11.3	18.6	15.4	9.2	11.3	0.8	2.7
18-24	4.2	28.3	6.5	9.2	18.6	12.9	16.5	6.7	0.8	4.8
24-30	4.8	30.6	3.8	13.8	15.8	10.8	15.6	5.8	2.9	6.9
30-36	6.0	22.5	0.4	26.0	17.5	12.7	17.1	7.7	2.9	1.0
36-42	4.4	22.3	2.9	29.2	24.2	8.5	18.3	5.8	1.7	0.2[c]
42-48	10.2	21.7	2.3	36.0	14.6	10.6	20.4	4.4	1.9	-
48-54	7.9	18.1	2.9	37.7	20.2	7.9	16.0	5.2	2.9	-
54-60	5.2	19.0	1.9	35.2	9.4	6.0	19.6	6.3	6.9	-
Overall average	6.2	24.6	3.3	25.0	17.4	11.3	15.6	6.2	2.5	3.4

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[a] MM5 run number.

[b] Observation periods are block periods; running 6-min averages were not calculated to determine the highest 6-min average.

[c] Observations discontinued.

TABLE 19. SUMMARY OF OPACITY OBSERVATIONS: TOTAL MINUTES AT SPECIFIED OPACITY LEVEL

Facility	NW Unit No. 1			NW Unit No. 2					EC 1	EC 2
Run No.[a]	4A/B	5A/B	6A/B	1A/B	2A/B	2A/B	3A/B	5C	7	8
Date	3/02/85	3/03/85	3/05/85	2/27/85	2/28/85	2/28/85	3/01/85	3/03/85	3/07/85	3/07/85
Observation begin time	1222	1030	1407	1545	1324	1609	1038	1631	1225	1700
Observation end time	1321	1129	1506	1644	1423	1708	1137	1730	1324	1744
Opacity level (%)	Observed minutes									
0	6.75	0	32.25	0	0	0	0	12.75	37.25	26.25
5	36.75	0	19	3	4.25	14.25	7	28	15.5	10
10	13.5	0.75	6.25	11.25	15	26.50	15.5	14.75	7.25	8
15	1.75	8.5	2.25	6.75	13.25	12.25	14.5	3.25		1.75
20	1.25	19.25	0.25	4.75	12	4.25	16.5	0.50		
25		9.75		4.25	8.25	2.25	0	0.25		
30		13.25		9.75	5.25	0.25	6.27	0.25		
35		5.5		12.75	1.75	0.25	0.25	0		
40		2.25		5.75	0			0.25		
45		0.75		1.75	0.25					
50										
55										
60										
65										
70										
75										
80										
85										
90										
95										
100										

[a] MRI run number.

4.5.1 MRI Quality Assurance Results

4.5.1.1 Particulate/HCl--

Table 20 reports the results of the blank analyses for the particulate and HCl sampling. No problems were identified.

4.5.1.2 PCDD/PCDF Analyses--

Audit results

Prior to initiating analysis of any samples, accuracy was checked by analyzing blind audit samples provided by MRI's Quality Assurance Unit. Two different samples were submitted to the laboratory; one sample was analyzed on two separate occasions. Results of the blind audit analyses are presented in Table 21. All accuracy results were within the range of 88 to 134%; the quality assurance objective of 60 to 115% accuracy, as assessed by the audit samples, was exceeded for some analyses.

ESP fly ash

Precision of the analysis for PCDDs and PCDFs in fly ash was assessed by conducting duplicate and triplicate analyses; accuracy was assessed by calculating percent recovery of the spiked surrogate. Table 22 summarizes the results of replicate analyses for the four ESP fly ash samples which were analyzed in duplicate. For each sample analyzed in duplicate the range percent difference was calculated for each homolog. Range percent is calculated as follows:

TABLE 20. PARTICULATE/HCl BLANK RESULTS

Sample No.	Type of blank	Measured value
157	Particulate, Filter No. 10	0.0003 g[a]
164	Particulate, acetone/hexane	0.0010 g/260 mL 0.004 mg/mL
166	HCl, water	0 µg/mL Cl^-
167	HCl, water	0 µg/mL Cl^-
168	HCl, KOH	6 µg/mL Cl^-
169	HCl, KOH	6 µg/mL Cl^-

[a] Difference between final weight and tare weight.

TABLE 21. RESULTS OF AUDIT SAMPLES

Sample	Analyzed	Analyte	Conc. (ng/μL) Actual	Conc. (ng/μL) Found	Accuracy (%)
QA-1	04/09/85	Tetra CDD	17	17.9	106
QA-1	04/09/85	Tetra CDF	17	17.7	104
QA-2	04/25/85	Tetra CDD	122	141	116
QA-2	04/25/85	Tetra CDF	122	145	119
QA-1	04/09/85	Penta CDD	17	22.8	134
QA-1	04/09/85	Penta CDF	17	17.2	101
QA-2	04/25/85	Penta CDD	122	159	130
QA-2	04/25/85	Penta CDF	122	155	127
QA-1	05/02/85	Hexa CDD	87	83	95
QA-1	05/02/85	Hexa CDF	87	87	100
QA-1	05/02/85	Hepta CDD	87	91	105
QA-1	05/02/85	Hepta CDF	87	91	105
QA-1	05/02/85	Octa CDD	173	176	102
QA-1	05/02/85	Octa CDF	173	153	88

TABLE 22. RESULTS OF REPLICATE ANALYSES FOR ESP FLY ASH SAMPLES

Analyte	Range percent difference for replicate analyses	
	Mean[a] (%)	Range of values (%)
2,3,7,8-TCDD	22	(8-33)
Tetra CDD	22	(14-35)
Penta CDD	30	(9-51)
Hexa CDD	46	(19-77)
Hepta CDD	38	(0-71)
Octa CDD	34	(5-56)
2,3,7,8-TCDF	16	(0-37)
Tetra CDF	26	(9-41)
Penta CDF	33	(8-56)
Hexa CDF	32	(6-59)
Hepta CDF	39	(6-63)
Octa CDF	30	(14-47)

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[a] Mean of range percent calculated for replicate analyses of four samples [runs 1,5,7,8].

$$R\% = \frac{C_1 - C_2}{\bar{C}} \times 100$$

where: C_1 = highest value determined
C_2 = lowest value determined
$\bar{C}$ = mean value of set

and

$$\bar{C} = \sum_{i=1}^{n} \frac{C_i}{n}$$

where: C_i = ith determination
n = number of determinations

The four precision values for each homolog obtained from the four samples were averaged to calculate the mean value reported in Table 22. The range of values for the calculated precision (range percent difference) of the four samples also are reported for each homolog in Table 22. For example, for 2,3,7,8-TCDD the range percent difference for the duplicate analyses of samples from runs 1, 5, 7, and 8 were 40, 8, 33, and 25%, respectively. Therefore, the mean precision value is [(40% + 8% + 33% + 25%) ÷ 4 = 27%]; the values ranged from (8 to 40%). The results generally were within the QA precision objective of $\leq$ 30% for 2,3,7,8-TCDD/TCDF, tetra CDD/CDF, and octa CDD/CDF, and $\leq$ 60% for the penta, hexa, and hepta CDD/CDF homologs.

Accuracy of the fly ash analyses was assessed by calculating the percent recovery for the surrogate $^{37}Cl_4$ TCDD. Table 23 reports the recovery results for the ESP fly ash. The calculated recoveries are very good and within the QA objective of 60 to 115%. The surrogate recovery of $^{37}Cl_4$-1,2,3,4,6,7,8-HPCDD could not be measured because of interference due to the large (relative to the spiked amount) quantity of 1,2,3,4,6,7,8-HPCDD in the samples. This is also true for the bottom ash and MM5 stack emission samples.

TABLE 23. RESULTS OF SURROGATE RECOVERY FOR FLY ASH SAMPLES

Run	% Accuracy[a]
1A/B (replicate 1)	105
1A/B (replicate 2)	73
1A/B (replicate 3)	102
2A/B	90
3A/B	NA[b]
4A/B	79
5A/B (replicate 1)	82
5A/B (replicate 2)	101
6A/B	96
7 (replicate 1)	95
7 (replicate 2)	69
8 (replicate 1)	89
8 (replicate 2)	97
8 (replicate 3)	82
8 (replicate 4)	99

[a] Percent recovery of $^{37}Cl_4$ TCDD.

[b] Not available; sample being reanalyzed.

Two fly ash method blanks and a field sample bottle blank were analyzed; all results were below detection limits.

Bottom ash

The same procedures that were used to assess precision and accuracy for the ESP fly ash samples were used for the bottom ash samples. Table 24 reports the precision results for replicate analyses and Table 25 reports the accuracy results as surrogate percent recovery.

The precision for the bottom ash samples is not as good as the precision measured for the fly ash samples. The nonhomogeneity of the bottom ash samples is expected to be the cause of the greater imprecision. The percent accuracy (surrogate recovery) is very good and within the desired range of 60 to 115%, with the exception of sample 4A/B (replicate 1) which was 53%.

Two bottom ash method blanks and a field sample bottle blank were analyzed; all results were below detection limits.

Stack emissions

Precision for the analysis of MM5 stack emissions samples was assessed by analyzing spiked blanks. Two filters and two XAD resin traps were spiked and analyzed. Table 26 reports the results of the analyses. The range percent differences were all less than 30%, except for one analyte which was 34%.

Accuracy for the MM5 samples was assessed by calculating percent recoveries for the surrogate $^{37}Cl_4$-TCDD for each emissions sample and the spiked blanks. Table 27 reports the surrogate recovery results. With the exception of run 6A, the surrogate recoveries were within the QA objectives (60 to 115%). Because the surrogate recovery on run 6A is so low (21%), the results from this sample should be considered as estimates.

TABLE 24. RESULTS OF REPLICATE ANALYSES FOR BOTTOM ASH SAMPLES

Analyte	Range percent difference for replicate analyses Mean[a] (%)	Range of values (%)
2,3,7,8-TCDD	54	(16-76)
Tetra CDD	41	(6-69)
Penta CDD	68	(36-96)
Hexa CDD	71	(32-98)
Hepta CDD	51	(40-78)
Octa CDD	37	(6-68)
2,3,7,8-TCDF	42	(25-64)
Tetra CDF	51	(41-63)
Penta CDF	65	(43-95)
Hexa CDF	64	(9-99)
Hepta CDF	61	(24-100)
Octa CDF	29	(0-81)

[a] Mean of range percent calculated for replicate analyses of four samples [runs 1, 5, 7, 8].

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TABLE 25. RESULTS OF SURROGATE RECOVERY FOR BOTTOM ASH SAMPLES

Run	% Accuracy[a]
1A/B (replicate 1)	85
1A/B (replicate 2)	99
2A/B	89
3A/B	85
4A/B (replicate 1)	53
5A/B (replicate 1)	96
5A/B (replicate 2)	94
6A/B	89
7A/B (replicate 1)	87
7A/B (replicate 2)	92
8A/B (replicate 1)	78
8A/B (replicate 2)	95
8A/B (replicate 3)	69

[a] Percent recovery of $^{37}Cl_4$ TCDD.

TABLE 26. RESULTS OF REPLICATE ANALYSES FOR MODIFIED METHOD 5 SAMPLES

	Range percent difference for replicate analyses	
Analyte	Spiked filter blank[a] (%)	Spiked XAD resin blank[a] (%)
2,3,7,8-TCDD	21	1
Tetra CDD	21	1
Penta CDD	13	10
Hexa CDD	29	5
Hepta CDD	34	18
Octa CDD	25	3
2,3,7,8-TCDF	7	2
Tetra CDF	7	2
Penta CDF	ND[b]	ND[b]
Hexa CDF	c	c
Hepta CDF	c	c
Octa CDF	28	13

[a] Two samples.

[b] Not detected.

[c] HxCDF and HpCDF not spiked.

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TABLE 27. RESULTS OF SURROGATE RECOVERY FOR MODIFIED METHOD 5 SAMPLES

Run	% Accuracy[a]
1A	58
2A	96
3B	100
4A	122
5A	96
6A	21
XAD spike (1)	80
XAD spike (2)	100
Filter spike (1)	101
Filter spike (2)	102
Blank train	103

[a] Percent recovery of $^{37}Cl_4$ TCDD.

A MM5 blank train was set up in the field and the recovered sample analyzed along with the emissions sample. The results of this blank train were reported in Table 9. With the exception of two analytes where very low levels were found (contamination from previous GC/MS injection suspected) all analytes were below the detection limit.

Control samples

In order to obtain data comparable to data obtained by other laboratories, two control samples were analyzed. The samples were National Bureau of Standards (NBS) urban dust and a fly ash composite ("Eastern Fly Ash"). The eastern fly ash (EFA) was provided by MRI and had been previously analyzed by MRI and other laboratories. Results of the analyses are provided in Table 28. Previously reported results for the NBS dust are 0.12 ng/g for 2,3,7,8-TCDD (plus four isomers) and 0.28 ng/g for TCDD. The previously reported result for the EFA is 2.0 ng/g for 2,3,7,8-TCDD. The results obtained during this project compare reasonably well with the results reported for the NBS dust and compare very well with the previously reported results for the EFA.

4.5.2 Second Laboratory Results (Triangle Laboratories, Inc.)

Samples from test run 5 were split and submitted to a second laboratory for analysis. The eight samples which were split and sent were:

1. ESP fly ash, replicate 1
2. ESP fly ash, replicate 2
3. Bottom ash, replicate 1
4. Bottom ash, replicate 2
5. NBS urban dust
6. Eastern coast fly ash (EFA)
7. MM5 extract
8. MRI calibration standard

TABLE 28. RESULTS FOR NBS DUST AND EASTERN FLY ASH

	Concentration ng/g			
	NBS replicate 1	NBS replicate 2	EFA replicate 1	EFA replicate 2
2,3,7,8-TCDD	0.06[a]	b	2.3[c]	1.9[c]
TCDD	0.12[a]	b	75	71
PCDD	2.2	b	230	220
HxCDD	3.8	5.3	b	112
HpCDD	19	16	b	68
OCDD	67	61	b	96
2,3,7,8-TCDF	0.21	b	4.0	4.2
TCDF	1.4	b	110	120
PCDF	3.1	b	160	170
HxCDF	d	0.94	b	108
HpCDF	4.7	4.9	b	76
OCDF	2.6	5.3	b	19

[a] Data reported by L. Lamparski and T. J. Nestrick (Anal. Chem. 1980, 52, 2045-54); TCDD (0.28 ng/g) and 2,3,7,8-TCDD plus four isomers (0.12 ng/g).

[b] Not analyzed.

[c] Data reported by Kuehl et al. (4th International Dioxin Symposium, Ottawa, October 1984); 2,3,7,8-TCDD (2.0 ng/g).

[d] Not detected.

The fly ash, bottom ash, NBS urban dust, and EFA were sent to the second laboratory for extraction and analysis; aliquots of the extracted MM5 sample and the calibration sample were sent for analysis. Table 29 summarizes the results of the analyses by the second laboratory. MRI's results for the same samples also are presented in Table 29 for comparison. Percent accuracy of the second lab compared to MRI's standard was calculated; the accuracy for the different homologs ranged from 27% (HxCDF) to 298% (HpCDD)).

TABLE 29. SECOND LABORATORY (TRIANGLE LABORATORIES, INC.) RESULTS

Lab[a]	Sample	% Surrogate recovery	2,3,7,8-TCDD	TCDD	P_5CDD	HxCDD	HpCDD	Octa CDD	2,3,7,8-TCDF	TCDF	P_5CDF	HxCDF	HpCDF	Octa CDF
							(ng/g)							
TL	Fly ash, Run 5 (rep. 1)	93	15.8	357	274	343	627	178	43.2	353	232	127	237	34
TL	Fly ash, Run 5 (rep. 2)	100	17.4	64	56	75	303	145	39.2	148	78	22	30	12.3
TL	Fly ash, Run 5 (dup. analysis)	107	18.3	63	72	95	345	152	b	154	78	22.5	25	8.1
MRI	Fly ash, Run 5 (rep. 1)	82	5.9	330	730	1,000	240	49	11	300	430	920	210	11
MRI	Fly ash, run 5 (rep. 2)	101	6.4	410	800	510	120	26	11	350	520	570	110	6.8
TL	Bottom ash, Run 5 (rep. 1)[d,h]	158	0.88	1.2	1.1	2.1	4.9	4.8	1.2	7.4	3.4	0.6	0.4	0.3
TL	Bottom ash, Run 5 (rep. 2)	109	0.72	2.9	2.5	3.9	10.6	5.8	1.3	5.9	3.4	0.9	0.7	0.3
MRI	Bottom ash, Run 5 (rep. 1)	96	0.77	33	71	35	11	5.9	1.1	25	29	24	7.8	0.95
MRI	Bottom ash, Run 5 (rep. 2)	94	0.41	16	25	12	4.8	2.9	0.69	13	16	8.1	2.6	0.4
TL	EFA[c,d]	97	4.6	6.6	4.9	17.8	93	351	8.9	28.3	17.5	5.5	2.9	6.7
MRI	EFA (rep. 1)	102	2.3	75	230	e	e	e	4	110	160	e	e	e
MRI	EFA (rep. 2)	92	1.9	71	220	112	68	96	4.2	120	170	108	76	19
	Literature value		2											
TL	NBS dust[d,h]	47	0.2	0.2	0.2	1.8	5.8	21	ND[f]	0.6	1	1.1	2.8	2.4
MRI	NBS dust (rep. 1)	106	0.059	0.12	2.2	3.8	19	67	0.21	1.4	3.1	ND	4.7	2.6
	Literature value		0.12	0.28										
								ng/sample						
TL	MM5[g]	97.6	9.4	426	318	386	265	78	b	1,110	838	367	158	22
MRI	MM5 (rep. 1)	96	11	370	1,100	1,200	450	170	36	900	1,100	1,300	390	32
MRI	MM5 (rep. 2)	-	e	e	e	860	390	130	e	e	e	800	290	25
								pg/µL						
TL	MRI standard	-	78.5	83.2	61.4	397	1,490	1,649	42.3	51.6	62	137	1,153	1,497
MRI	MRI standard	-	100	-	100	500	500	1,000	100		100	500	500	1,000
	Percent accuracy versus MRI standard		78.5	-	61.4	79.4	298	165	42.3		62	27.4	231	150

[a] TL = Triangle Labs; MRI = Midwest Research Institute.

[b] Not available; peak outside acceptance window.

[c] Eastern fly ash.

[d] High signal to noise ratio; results should be considered estimated.

[e] Not analyzed.

[f] Not detected.

[g] MM5 = Modified Method 5 stack emissions sample.

[h] Percent recovery outside EPA acceptance range (60-140% recovery).

SECTION 5.0

SAMPLING AND ANALYSIS PROCEDURES

This section briefly describes the sampling, sample recovery/preparation, and analytical procedures used during the test program. Table 30 presents an overview of the sampling/analysis protocol.

Section 5.1 identifies the sampling locations. Section 5.2 presents the sampling procedures and the sample recovery/handling procedures. Section 5.3 briefly describes the analytical procedures.

5.1 SAMPLING LOCATIONS

5.1.1 Stack Emissions

Figure 2 identifies the MM5 sampling locations for the NW Units 1 or 2 (units are nearly identical). The sample was collected at 24 traverse points chosen according to EPA Reference Method 1 (40CFR60). The CEM sampling location for the NW units also is shown in Figure 2; the CEM sample was taken from a single point in the stack of each unit.

The continuous emission monitor sampling location for the EC Units 1 or 2 is depicted in Figure 3; the sample was taken from a single point in the breeching of each unit.

TABLE 30. SAMPLING AND ANALYSIS AT FOUR CITY OF PHILADELPHIA INCINERATORS

Sample	Sampling method/frequency	Analysis parameters	Number of runs at each unit[a,b]			
			NW 1	NW 2	EC 1	EC 2
A. Operating parameters	Record plant instrument readings every 1/2 hr.	Feedrate; incinerator temperature; incinerator pressure; ESP parameters.	3	3	1	1
B. Bottom ash	Grab samples taken every 1/2 hr and composited into one sample.	PCDD/PCDF[c]	3	3	1	1
C. ESP ash	Grab samples taken every 1/2 hr and composited into one sample.	PCDD/PCDF[c]	3	3	1	1
D. Stack gas	Continuous monitoring over the test period.	CO_2, CO, O_2, SO_2, HC, NO_x.	3	3	1	1
	Visual (EPA Method 9) 1-hr during the test period.	Opacity	3	3	1	1
	MM5-Train A (4 hr)	Particulate, HCl	3	3	0	0
	MM5-Train B (4 hr)	PCDD/PCDF[c]	3	3	0	0
	MM5-Train C (blank)	PCDD/PCDF[c]	1	0	0	0

[a] NW 1 = Northwest incinerator Unit 1, NW 2 = Northwest incinerator Unit 2.
EC 1 = East Central incinerator Unit 1, EC 2 = East Central incinerator Unit 2.

[b] First test at Northwest Unit 2 was 192 min, all other tests at NW incinerator were 240 min; tests at EC incinerator were 180 min.

[c] 2,3,7,8-TCDD, 2,3,7,8-TCDF, Tetra CDD, Penta CDD, Hexa CDD, Hepta CDD, Octa CDD, Tetra CDF, Penta CDF, Hexa CDF, Hepta CDF, Octa CDF.

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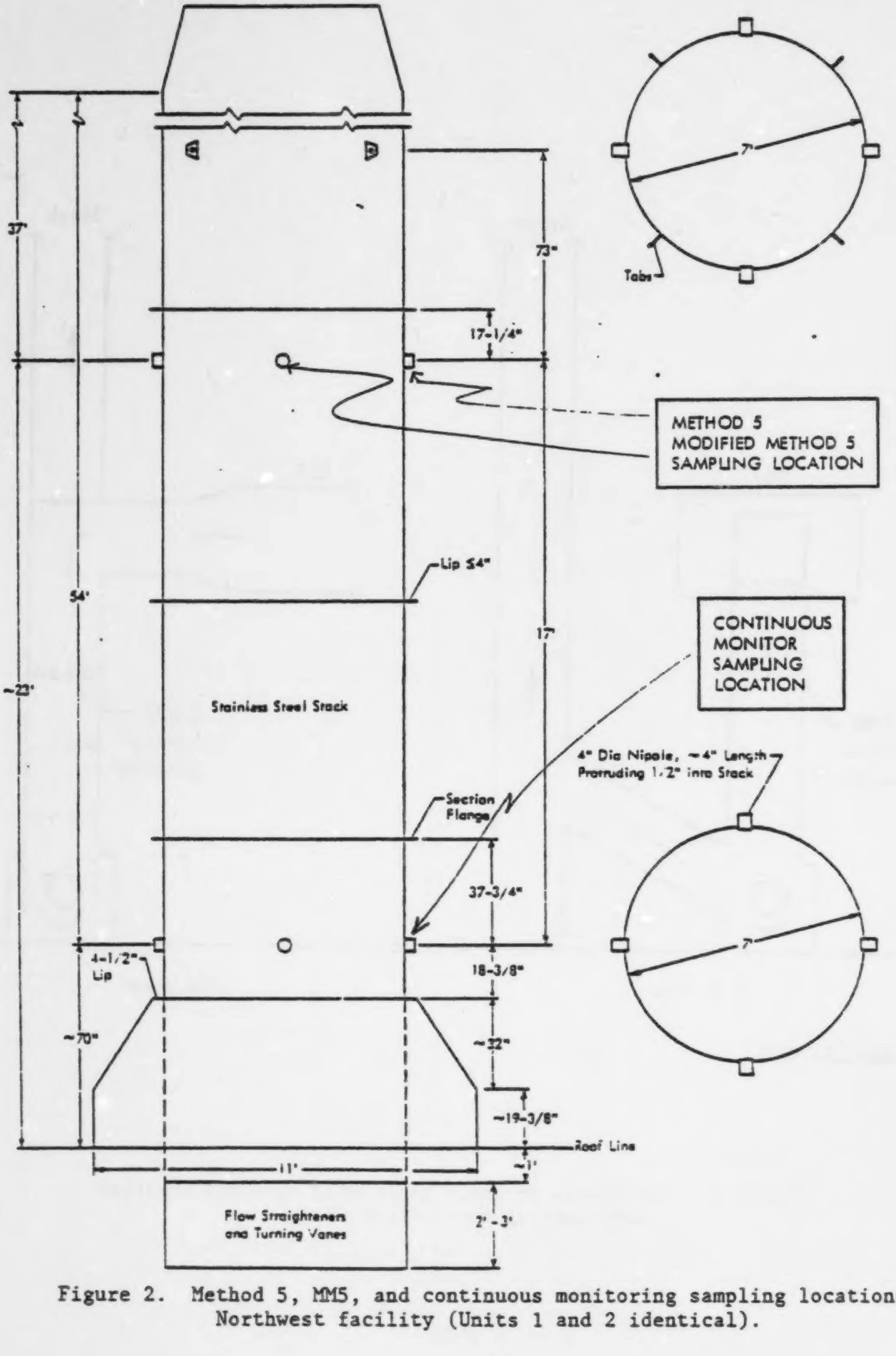


Figure 2. Method 5, MM5, and continuous monitoring sampling locations, Northwest facility (Units 1 and 2 identical).

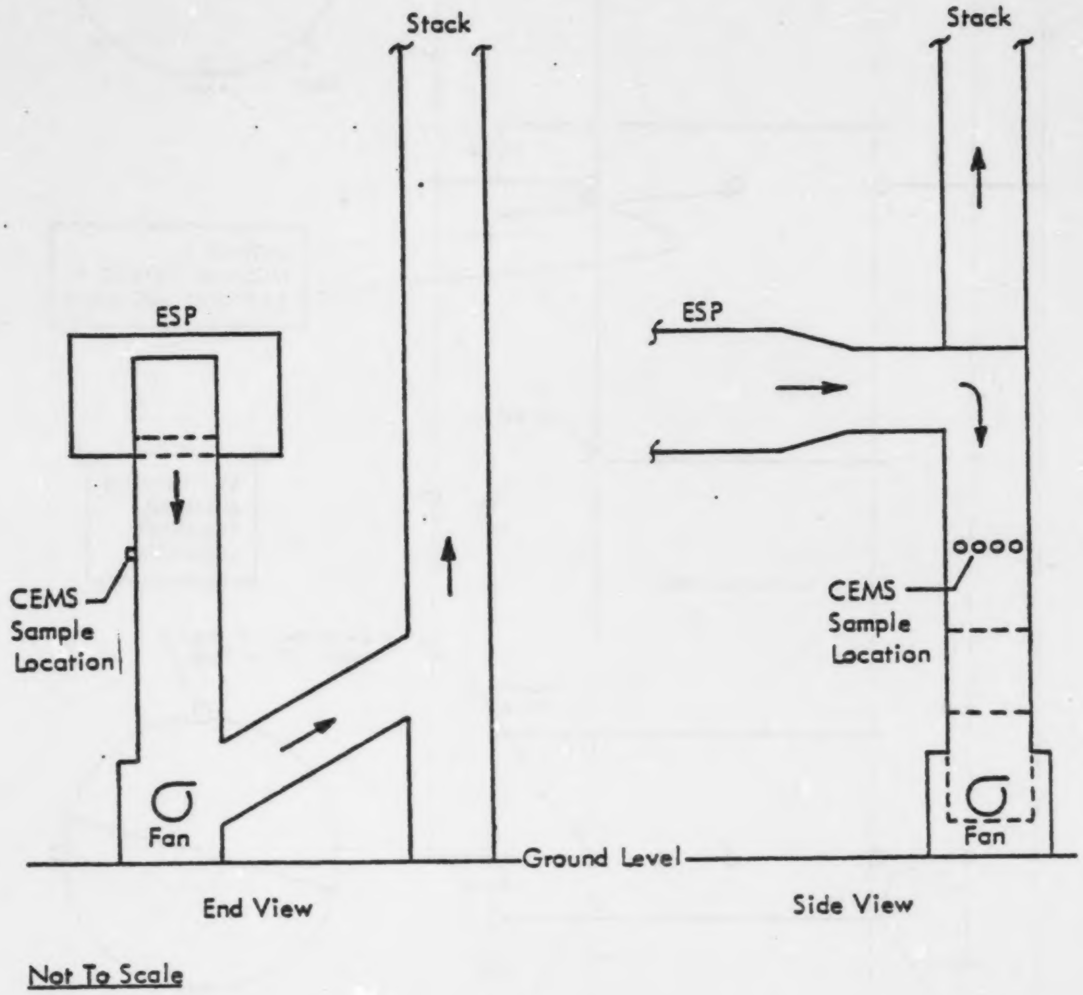


Figure 3. Continuous emission monitoring sampling location East Central incinerator.

60<

5.1.2 Fly Ash

For both units the ESP fly ash is discharged to the atmosphere just above the wasting pit. The fly ash samples were taken from the discharge of the ESP hoppers before the ash entered the wasting pit.

Figure 4 shows the ESP ash sampling locations for the NW facility. Sampling locations for Units 1 and 2 are essentially the same. The fly ash samples were taken from locations C and D (Figure 4); grab samples were taken alternately from locations C and D.

Figure 5 shows the ESP fly ash sampling location for the East Central incinerator Units 1 and 2. The units are essentially the same. At the EC facility there is a single ESP screw feed (for each unit) to the waste pit; therefore, all ESP fly ash samples were taken from point C (Figure 5).

5.1.3 Bottom Ash

The bottom ash samples were taken from the inclined grate at the discharge end of the waste pit; the location is depicted as location E, Figure 4, for the NW facility units; the bottom ash sampling location for the EC units is depicted as location D, Figure 5. Note that at this sampling location the bottom ash is composed of both the ESP fly ash and the furnace bottom ash.

5.2 SAMPLING AND SAMPLE HANDLING PROCEDURES

Table 30 summarized the sampling procedures used during the test program. The following paragraphs briefly describe the sampling and sample handling procedures used in the field.

5.2.1 Fly Ash Sampling

Individual grab samples of the fly ash were collected at 1/2-hr intervals during the test period.

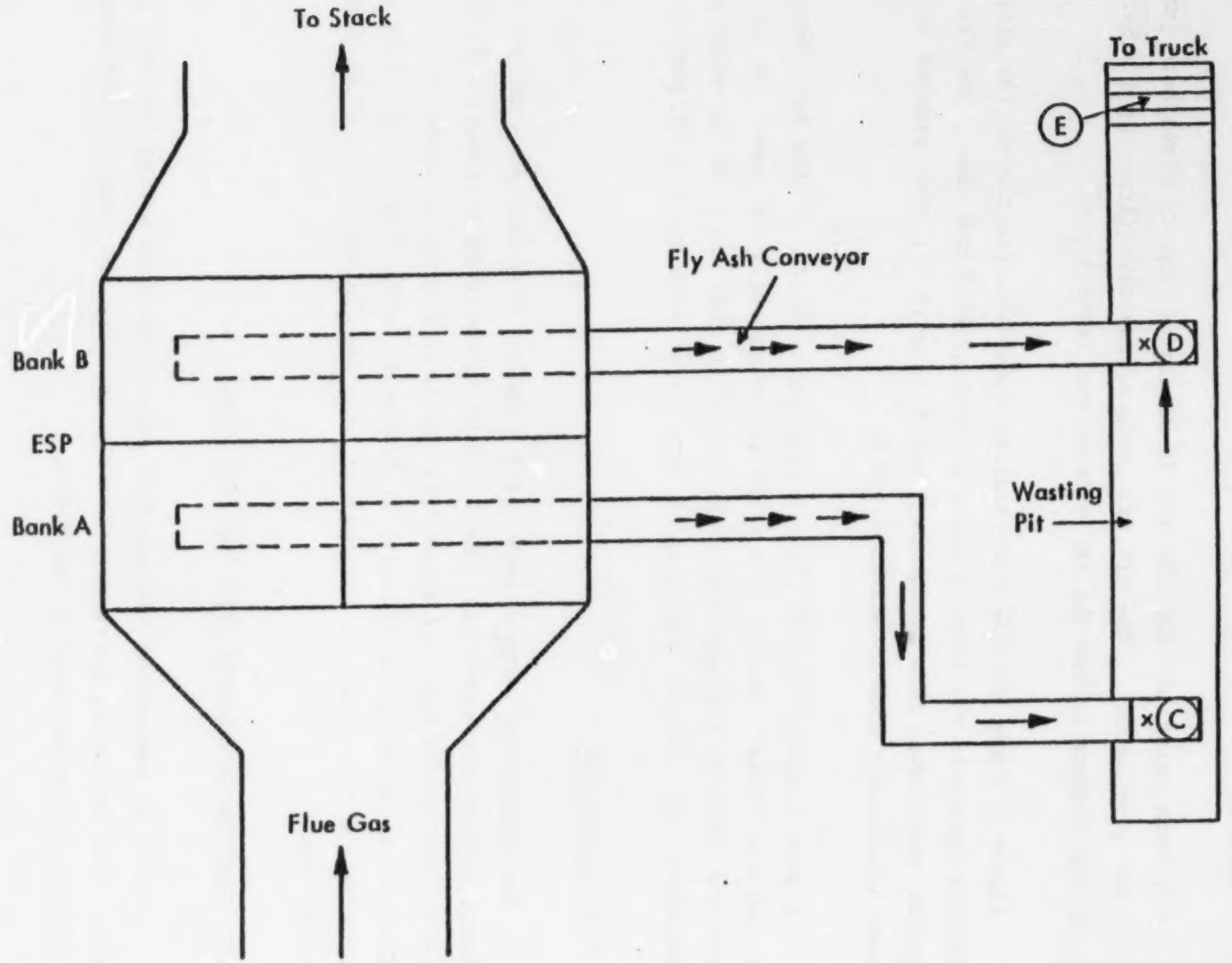


Figure 4. Ash sampling locations NW facility (Units 1 and 2 identical).

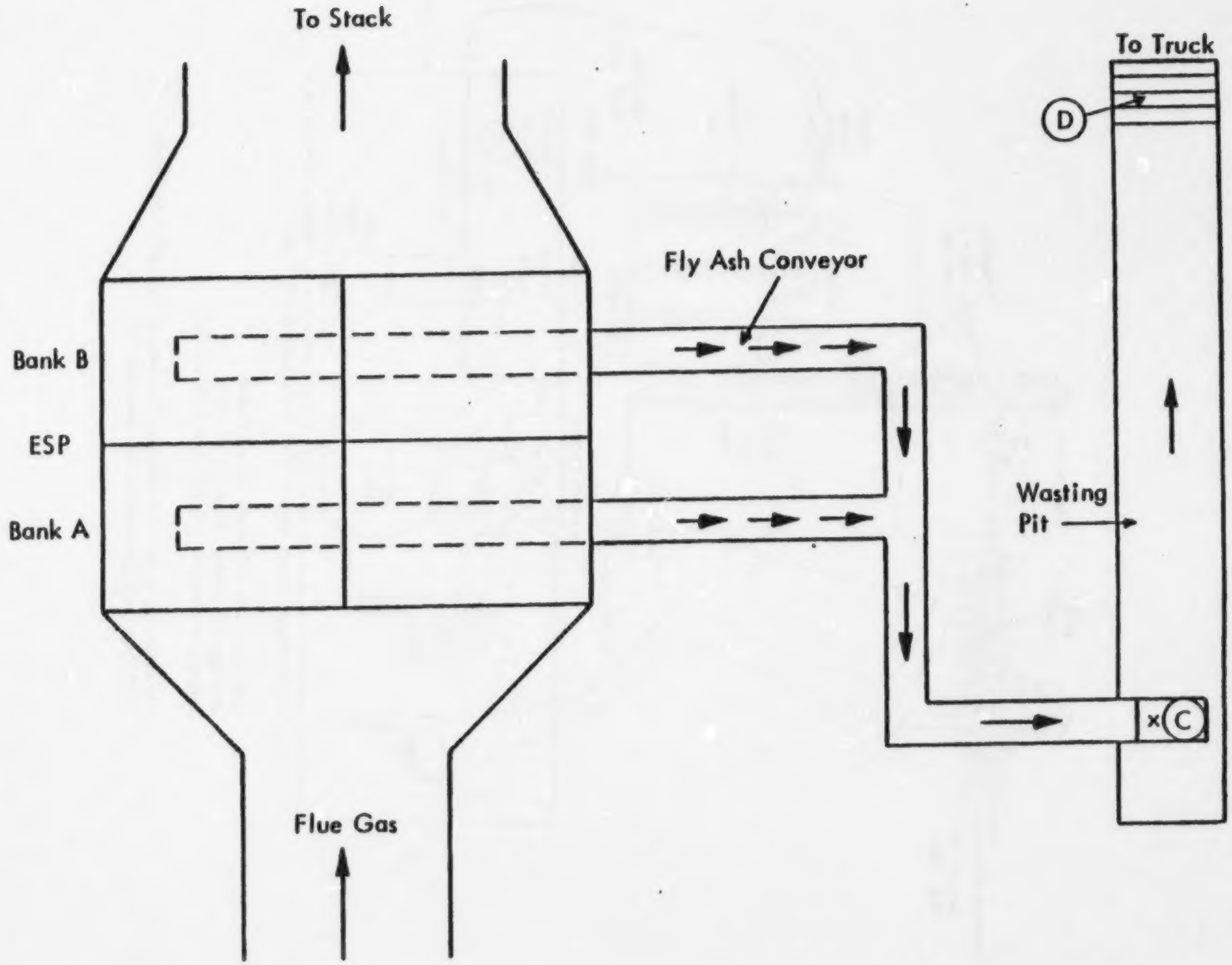
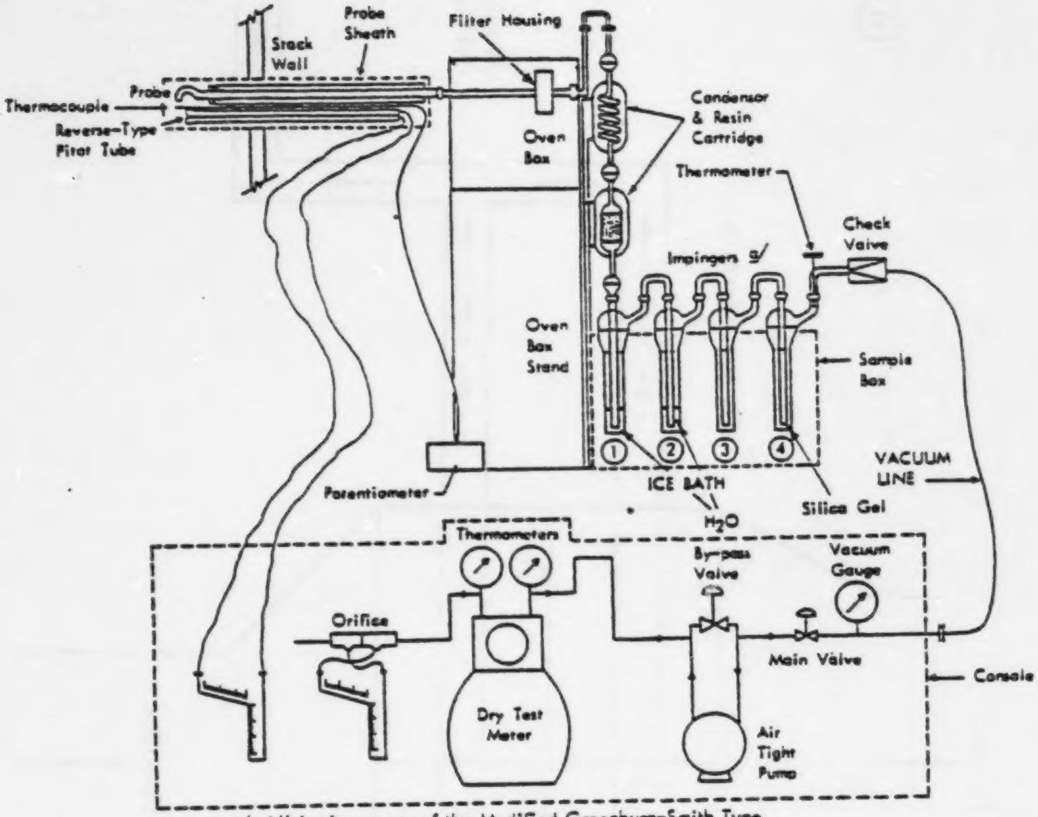


Figure 5. Ash sampling locations East Central facility (Units 1 and 2 identical).



a/ All Impingers are of the Modified Greenburg-Smith Type

Impinger 1 and 2 Contain 100 ml Water
Impinger 3 Contains 100 ml 0.1 N KOH
Impinger 4 Contains 200-300 Grams Silica Gel

All Joints Up to and Not Including the Second Impinger Have Viton "O" Rings, All Other Joints Use Apiezon "L"

Figure 6. Modified Method 5 (MM5) train.

Impinger 1: 100 mL water
Impinger 2: 100 mL water
Impinger 3: 100 mL 0.1 N KOH
Impinger 4: 200 g silica gel

One of the requirements of the method is that no grease be used for sealing joints in the train. Viton® O-rings were used to seal all joints prior to and including the first impinger; Apeiezon "L" grease was used for sealing the remaining impinger joints.

With the exception of Run 1, the sampling time for each test was 4-hr (240 min); test 1 was 192 min long. The sampling time was increased after test 1 to increase the sample volume collected to over 3 m^3.

Sample recovery--Both sampling trains were recovered using identical procedures. The containers recovered included:

Container 1:	Probe, nozzle, and filter front half rinse (hexane/acetone)
Container 2:	Filter
Container 3:	XAD resin cartridge
Container 4:	Hexane/acetone rinse of filter back half, condensor, and glassware connecting the filter and condensor ("organic rinse")
Container 5:	First impinger condensate and organic rinse of impinger
Container 6:	Second impinger condensate and impinger rinse
Container 7:	Third (KOH) impinger contents and impinger rinse
Container 8:	25-mL aliquot of first impinger condensate (for HCl analyses)

The contents of all four impingers were gravimetrically measured during sample recovery to calculate stack gas percent moisture.

All samples were recovered in the field laboratory; the samples were stored in chilled containers in the field, during transport to the laboratory, and at the laboratory.

Oxygen measurement

An integrated bag sample was collected according to the procedures of EPA Reference Method 3. The bag sample was collected from a single point in the stack throughout the duration of the MM5 test. The sample was analyzed for oxygen and carbon dioxide by Orsat immediately after the test. The measured carbon dioxide concentration was used to correct the measured particulate concentration to a 12% CO_2 concentration basis.

5.2.3.2 Continuous Emission Monitoring--

Stack effluent gases were continuously monitored during each 4-hr test period. The gas sample was drawn from a single point in the stack through a single heated Teflon line to a common sampling manifold mounted in a field van. The gas sample was split from the manifold so that all monitors continuously obtained a sample of the gas. Figure 7 is a simplified schematic of the continuous emission monitoring system. Gases monitored and the instruments used are shown in Table 31. Prior to initiating any testing, the calibration of each monitor was checked and documented by a three-point calibration. All calibration gases were certified calibration gases (certified ±2% accuracy by the manufacturer); to verify monitor calibration, one of the three gases used for calibration of each monitor was an EPA protocol gas. Before every run, each monitor was zeroed and spanned with zero and high level calibration gases. At the completion of every run, the calibration of each instrument was rechecked, and documented using the same zero/span gases. Sample line integrity was verified prior to each run by plugging the sample line inlet and monitoring the gas volumetric flow rate at the manifold to assure a no-flow condition.

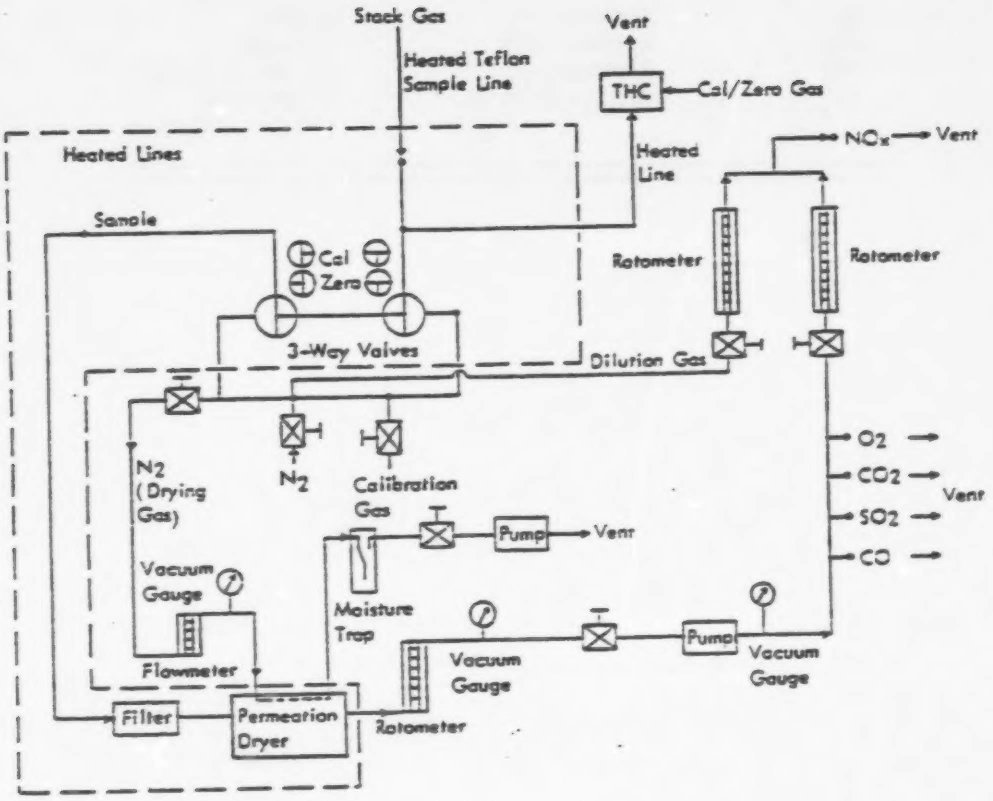


Figure 7. Simplified schematic of continuous monitoring system.

TABLE 31. SUMMARY OF CONTINUOUS MONITORING PARAMETERS

Parameter	Monitor	Instrument range
CO_2	Horiba PIR-2000	0-15%
CO	Horiba PIR-2000	0-1,700 ppm
O_2	Beckman 741	0-25%
SO_2	Beckman 865	500 ppm
THC	Beckman 402	10 ppm propane
NO_x	Bendix 8101-R	5 ppm with 1:50 dilution

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5.2.3 Opacity--

A certified (Method 9) opacity reader recorded stack opacity readings every 15 sec per EPA Method 9. The visible emission observers were EPA inspectors from Region III.

5.3 ANALYTICAL PROCEDURES

5.3.1 PCDD/PCDF Analyses

A brief summary of the procedures used for compositing, extracting, and analyzing the samples for PCDDs and PCDFs are presented in the following paragraphs.

5.3.1.1 Sample Compositing--

Fly ash

For each test run, 10 g of each of the 10 grab samples were composited to form a single composite fly ash sample. Therefore, the final composite fly ash sample was 100 g, except for run 1 which was 80 g (run 1 was a shorter test); a 10 g aliquot of the composite was taken for extraction.

Bottom ash

The bottom ash samples presented some problems for compositing since the samples were very wet and contained materials of varying size fractions (glass, wire, bottle tops, etc.). In order to achieve more uniform composites, the bottom ashes were air dried and separated into three size fractions. A 0.250-in. mesh screen was used to separate the largest pieces of debris (fraction 1) from the composited materials. A second cut of the bottom ashes using a 0.0937-in. sieve resulted in the removal of additional fragments of glass, rock, paper, etc. (fraction 2). The resulting sieved materials (fraction 3) were mixed well and were analyzed as the final composites. Table 32 provides the masses of the three size fractions for the composited bottom ash samples.

TABLE 32. SAMPLE COMPOSITES - BOTTOM ASH

Run No.	Composite fraction	Mass	Laboratory sample No.[b]	Extract sample No.
1	Fraction 1	c	120-BA-8281	121-BA-8281-14
	Fraction 2	196 g		122-BA-8281-15
	Fraction 3	373 g		(duplicate)
	Total	569+g		
2	Fraction 1	c	220-BA-8281	220-BA-8281-16
	Fraction 2	195 g		
	Fraction 3	330 g		
	Total	525+g		
3	Fraction 1	c	320-BA-8281	320-BA-8281-17
	Fraction 2	111 g		
	Fraction 3	198 g		
	Total	309+g		
4	Fraction 1	111 g	420-BA-8281	420-BA-8281-18
	Fraction 2	147 g		
	Fraction 3	238 g		
	Total	496 g		
5	Fraction 1	341 g	520-BA-8281	521-BA-8281-19
	Fraction 2	249 g		522-BA-8281-20
	Fraction 3	410 g		(duplicate)
	Total	1,000 g		
6	Fraction 1	28 g	620-BA-8281	620-BA-8281-21
	Fraction 2	48 g		
	Fraction 3	206 g		
	Total	282 g		
7	Fraction 1	128 g	720-BA-8281	721-BA-8281-21
	Fraction 2	131 g		722-BA-8281-22
	Fraction 3	176 g		(duplicate)
	Total	435 g		
8	Fraction 1	105 g	820-BA-8281	821-BA-8281-23
	Fraction 2	127 g		822-BA-8281-34
	Fraction 3	167 g		823-BA-8281-35
	Total	399 g		(triplicate)

---

[a] Contents of all field samples were combined, mixed, and allowed to air dry. Each composited sample was sieved through a 0.250-in. mesh screen. The residual materials from this step are classified as fraction 1. The sieved material was taken through a second sieve (0.0937 in.). The retained material is considered fraction 2 and the sieved material is fraction 3.

[b] Fraction 3 was given the laboratory sample number. Fractions 1 and 2 were returned to the sample bottles.

[c] This material was erroneously discarded prior to weighing.

MM5 samples

The MM5 sample fractions for each test run were:

a. filter
b. XAD resin
c. first impinger contents/rinse ("condensate")
d. back-half organic rinse
e. front half probe rinse

For each run, the back-half organic rinse and the front-half probe rinse were combined prior to extraction. All other fractions were extracted separately, and the extracts combined for analysis (see Section 5.3.1.2 for extraction procedures).

5.3.1.2 Sample Extraction--

MM5 trains

Each MM5 sample consisted of the components presented in Table 33. For each run, one component of the MM5 train was spiked with 20 µL of a solution containing the internal standards and surrogates as specified in Table 33. The composition of the spiking solution is presented in Table 34. The final impinger contents (water/hexane) were allowed to come to room temperature, spiked as necessary, and transferred to 1-L separatory funnels. The contents were shaken vigorously, allowed to separate, and the hexane fractions were removed. The aqueous condensates were each extracted with three aliquots of 60 mL of methylene chloride (Burdick and Jackson, distilled in glass). The methylene chloride extracts were combined with the hexane fraction and the combined extracts were back extracted with Milli-Q water. The organic layers were separated, dried over sodium sulfate, and stored in a walk-in cooler until combined with the remaining train component extracts.

The organic rinses and MM5 probe rinses were spiked (20 µL of internal standards and surrogates solution), where necessary, and were concentrated

TABLE 33. MODIFIED METHOD 5 SAMPLE FRACTIONS AND SPIKING SCHEME

	Fraction spiked						
	Run						
Sample fraction	1	2	3	4	5	6	Blank
Filter	X					X	
XAD resin		X			X		
First impinger condensate and rinse			X				
Organic/probe rinse				X			X

TABLE 34. SPIKING SOLUTION

Compound	Mass of compound in 20 µL
$^{13}C_{12}$-2,3,7,8-TCDD	2.5 ng
$^{37}Cl_4$-2,3,7,8-TCDD	12 ng
$^{13}C_{12}$-2,3,7,8-TCDF	2.5 ng
$^{37}Cl_4$-1,2,3,4,6,7,8-HpCDD	10 ng
$^{13}C_{12}$-OCDD.	10 ng

using flowing prepurified nitrogen to approximately 5 mL. The extracts and associated particulate were quantitatively transferred to 6-dram vials with additional hexane rinses and were concentrated to 1 mL.

The MM5 filters and particulate were placed in Soxhlet apparatus. The filter samples for runs 1 and 6 were spiked with 20 µL of the surrogate and internal standards. The combined organic rinses and MM5 probe rinses were added to the respective filter extractions. The extractors were charged with 350 mL of benzene and the systems were allowed to cycle for 16 hr. The extracts from this procedure were combined with the first impinger extracts and were concentrated to 2 mL using Kuderna-Danish evaporators and flowing prepurified nitrogen.

The contents of the MM5 XAD-2 resin cartridges were transferred to large Soxhlet extractors. Samples from runs 2 and 5 were each spiked with 20 µL of the internal standard and surrogate spiking solution. The Soxhlet apparatus were charged with 500 mL of benzene (Burdick and Jackson, distilled in glass) and were allowed to extract for at least 16 hr. The resulting extracts were combined with the extracts from the other MM5 train components and reduced in volume to 1 mL using Kuderna-Danish evaporators and flowing prepurified nitrogen.

One complete MM5 field blank was prepared along with the actual samples. In addition, a laboratory method blank was prepared to parallel all actual sample preparations.

Fly ash/bottom ash samples

Ten-gram aliquots of the composite fly ash samples were each mixed with anhydrous sodium sulfate, spiked with 200 µL of the internal standard/surrogate spiking solution, and transferred to Soxhlet extractors. Each extractor was charged with 350 mL of benzene and the samples were extracted overnight (16 hr). The extracts were removed and concentrated as described above.

Replicate sample analyses were completed for runs 1, 5, 7, and 8. Two fly ash method blanks and one field blank were extracted along with the actual samples. However, only 20 µL of the internal standard/surrogate spiking solution was added to the blanks.

Bottom ash samples were prepared following the same procedures as discussed for the fly ash except 20-g aliquots of the bottom ash composites were spiked with 20 µL of the internal standard/surrogate spiking solution.

5.3.1.3 Extract Cleanup--

All sample extracts were cleaned using a two-part column chromatography procedure. The first column (1 x 30 cm) was packed with 1.0 g of silica gel and 4.0 g of 40% (w/w) sulfuric acid modified silica gel. The second column (1 x 30 m) was packed with 6.0 g of acidic alumina topped with 1 cm of anhydrous sodium sulfate. The sample extracts were added at approximately 1-mL final volume in benzene to the silica/sulfuric acid modified silica column, followed by 90 mL of hexane. This eluent was collected and eluted through the acidic alumina column, followed by 45 mL of additional hexane and 20 mL of 20% methylene chloride in hexane. The 20% methylene chloride fraction was collected for PCDD/PCDF analysis. The extracts were concentrated using flowing prepurified nitrogen and transferred to 1-mL reactivials. The final extracts were concentrated just to dryness and refrigerated until HRGC/MS analysis.

5.3.1.4 High Resolution Gas Chromatography/Mass Spectrometry (HRGC/MS) Analysis--

The sample extracts were analyzed by high resolution gas chromatography/mass spectrometry with selected ion monitoring (HRGC/MS-SIM) using the parameters specified in Table 35. The level of the PCDDs and PCDFs were calculated by comparison of the response of the samples to calibration standards which contained the compounds listed in Table 36.

TABLE 35. INSTRUMENT AND OPERATING PARAMETERS FOR HRGC/MS-SIM ANALYSES OF PCDDs/PCDFs

Instrument: Finnigan MAT 311A

Column: 60-m fused silica, wall-coated with SP-2330 (TCDD/F-P_5CDD/F) or with DB-5 (HxCDD/F-OCDD/F)

Column temperature: 110°C hold 2 min, 10°C/min to 340°C, hold 10 min (HxCDD/F-OCDD/F)

Carrier gas: Helium

Injector: Grob type split/splitless (1-µL injection)

Mass resolution: ~ 1,000 (M/ΔM, 10% valley)

Ions measured:

Homolog	Dioxins (m/e)	Furans (m/e)	PFK (reference)	Diphenyl ether Interference
Tetrachloro-	319.9/321.9	303.9/305.9	330.9	373.8
Pentachloro-	355.9/357.9	337.9/339.9		407.8
Hexachloro-	389.8/391.8	373.8/375.8	380.9	443.7
Heptachloro-	423.8/425.8	407.8/409.8		477.7
Octachloro-	457/459.7	441.7/443.7		511.7
Internal standards				
Tetrachloro- ($^{37}Cl_4$)	327.9	-	330.9	
Tetrachloro- ($^{13}C_{12}$)	331.9/333.9	315.9/317.9		
Heptachloro- ($^{37}Cl_4$)	329/331		380.9	
Octachloro ($^{13}C_{12}$)	469.7/471.71	-		

TABLE 36. ANALYTICAL STANDARDS AND SOURCES

Analyte	Compounds in calibration standard	Source	Internal quantitation standard
Tetra-CDD	2,3,7,8-TCDD	EPA QA Materials Branch	2,3,7,8-TCDD-$^{13}C_{12}$[a]
$^{37}Cl_4$-Tetra-CDD	$^{37}Cl_4$-2,3,7,8-TCDD	KOR Isotopes	2,3,7,8-TCDD-$^{13}C_{12}$
Tetra-CDF	2,3,7,8-TCDF	Cambridge Isotope Laboratories	2,3,7,8-TCDF-$^{13}C_{12}$
Penta-CDD	1,2,3,7,8-P_5CDD	Cambridge Isotope Laboratories	2,3,7,8-TCDD-$^{13}C_{12}$
Penta-CDF	1,2,3,8,9-P_5CDF	Cambridge Isotope Laboratories	2,3,7,8-TCDF-$^{13}C_{12}$
Hexa-CDD	1,2,3,4,7,8-HxCDD	Cambridge Isotope Laboratories	OCDD-$^{13}C_{12}$
Hexa-CDF	1,2,3,4,7,8-HxCDF	Cambridge Isotope Laboratories	OCDD-$^{13}C_{12}$
Hepta-CDD	1,2,3,4,6,7,8-HpCDD	Cambridge Isotope Laboratories	OCDD-$^{13}C_{12}$
$^{37}Cl_4$-Hepta-CDD	$^{37}Cl_4$-1,2,3,4,6,7,8-HpCDD	KOR Isotopes	OCDD-$^{13}C_{12}$
Hepta-CDF	1,2,3,4,6,7,8-HpCDF	Cambridge Isotope Laboratories	OCDD-$^{13}C_{12}$
Octa-CDD	OCDD	Ultra Scientific	OCDD-$^{13}C_{12}$
Octa-CDF	OCDF	Ultra Scientific	OCDD-$^{13}C_{12}$

---

[a] The $^{13}C_{12}$-2,3,7,8-TCDD, $^{13}C_{12}$-2,3,7,8-TCDF, and the $^{13}C_{12}$-OCDD were from Cambridge Isotope Laboratories.

Concentrations of each dioxin or furan homolog were calculated by first calculating a relative response factor, then calculating a final concentration in nanograms per sample using the following equations, which are an example for TCDD.

$$\text{Relative Response Factor (RRF)} = \frac{A_{(std)}}{A_{(IS)}} \times \frac{C_{(IS)}}{C_{(std)}}$$

where:

$A_{(std)}$ = area of ions m/z 320 and 322 for the unlabeled 2,3,7,8-TCDD in the standard

$A_{(IS)}$ = area of ions m/z 332 and 334 for the $^{13}C_{12}$-2,3,7,8-TCDD in the standard

$C_{(IS)}$ = concentration of $^{13}C_{12}$-2,3,7,8-TCDD in the standard

$C_{(std)}$ = concentration of unlabeled 2,3,7,8-TCDD in the standard (ng)

$$C_{(sample)} = \frac{A_{(sample)}}{A_{(IS)}} \times \frac{C_{(IS)}}{RRF}$$

where:

$C_{(sample)}$ = total concentration of all TCDD isomers in the sample (ng)

$A_{(sample)}$ = total area of ions m/z 320 and 322 for all TCDD isomers in the sample

$A_{(IS)}$ = area of ions m/z 332 and 334 for the $^{13}C_{12}$-2,3,7,8-TCDD in the sample

$C_{(IS)}$ = concentration of $^{13}C_{12}$-2,3,7,8-TCDD in the sample (ng)

The concentration of total TCDF was calculated with the above equations using the response of ions m/z 304 and 306 to measure the concentration of unlabeled TCDF and the response of ions m/z 316 and 318 for the $^{13}C_{12}$-2,3,7,8-TCDF. Similar procedures were used for each of the PCDD/PCDF homologs. Table 36 indicates the internal standard used to calculate the RRF values for each of the PCDD/PCDF homologs.

The calibration standard included 2,3,7,8-TCDD and 2,3,7,8-TCDF; therefore, concentrations of these isomers in the stack gas emissions were determined by quantifying directly against the internal standard.

Stack gas concentrations of specific 2,3,7,8-substituted isomers for the penta-hepta dioxin and furan homologs also were of interest. There are thirteen 2,3,7,8-substituted dioxin/furan isomers; these are listed in Table 37. Nine of the 13 isomers were identified by matching their retention times to the retention time of the isomer included in the calibration standard. Information on relative retention times was provided by the two sources:

1. Rappe, C., "Analysis of Polychlorinated Dioxins and Furans," Environ. Sci. Tech., 18, 78A-90A (1984).

2. Hale, D. H., F. D. Hileman, T. Mazer, T. L. Shell, R. W. Noble, and J. J. Brooks, "Mathematical Modeling of Temperature Programmed Capillary Gas Chromatographic Retention Indexes of Polychlorinated Dibenzofurans," Anal. Chem., 57 640-648 (1985).

Once the isomer peaks were identified, concentrations were calculated using peak areas and the relative response factor previously calculated for each homolog.

5.3.2 Particulate Matter Concentrations

The probe rinse and particulate filter from the separate sample train designated as the particulate sample (train B, except run 3) were analyzed gravimetrically according to EPA Reference Method 5 procedures. The probe rinse was transformed to a tared 250 mL beaker, evaporated to dryness at room temperature, desiccated for 24 hr and weighed to a constant weight. The filter was desiccated for 24 hr and weighed to a constant weight.

TABLE 37. 2,3,7,8-SUBSTITUTED DIOXIN/FURAN ISOMERS

Isomer	Results reported[a]
1,2,3,7,8 P_5CDD	Yes
1,2,3,7,8 P_5CDF	Yes (with 1,2,3,4,8 PCDF)
2,3,4,7,8 P_5CDF	Yes
1,2,3,4,7,8 HxCDD	Yes
1,2,3,6,7,8 HxCDD	No
1,2,3,7,8,9 HxCDD	No
1,2,3,4,7,8 HxCDF	Yes
1,2,3,6,7,8 HxCDF	Yes
2,3,4,6,7,8 HxCDF	No
1,2,3,7,8,9 HxCDF	No
1,2,3,4,6,7,8 HpCDD	Yes
1,2,3,4,6,7,8 HPCDF	Yes
1,2,3,4,7,8,9 HpCDF	Yes

---

[a] Stack gas concentration results are reported in Tables 10 and 11.

5.3.3 HCl Analysis

The first, second, and third impinger contents/rinse of the designated particulate sampling train were analyzed for Cl^-. A Technicon autoanalyzer was used to conduct the analyses by the colorimetric, ferricyanide method (Method 325.2, "Methods for Chemical Analysis of Water and Wastes," EPA-600/4-79-020, March 1979).

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
841 Chestnut Building
Philadelphia, Pennsylvania 19107

SUBJECT: Ambient Air Dioxin Concentration Predictions for the Philadelphia Northwest Incinerator

DATE: JAN 10 1986

FROM: Alan J. Cimorelli
Source Emissions & Evaluation Section (3AM12)

TO: W. Ray Cunningham, Director
Air Management Division (3AM00)

THRU: James E. Sydnor, Chief
Air Programs Branch (3AM10)

Lewis K. Felleisen, Chief
Source Emissions & Evaluation Section (3AM12)

In order to assess the risk to public health caused by dioxin emissions from Philadelphia's Northwest Municipal Incinerator (NWI), an air diffusion modeling study coupled with a risk assessment analysis via the Human Exposure Model (HEM) was performed. Considering the area in the vicinity of this incinerator, as well as its physical plant, it was found necessary to perform the air diffuusion modeling with techniques other than those found in HEM. Therefore, although the actual assessment of risk was accomplished via HEM, the concentration prediction algorithms within HEM were not used. The field of ambient air concentrations were predicted external to HEM and then provided as input to HEM for calculations of individual risk and annual incidence.

The purpose of this memorandum is to document only the air diffusion modeling portion of this study; the procedures used and results obtained are discussed in the paragraphs that follow. The risk assessment portion of this study is documented in an accompanying memorandum prepared by David Cleverly, OAQPS and titled "Estimated Risk Assessment of Exposure to PCDD/PCDF Emissions from the Philadelphia Northwest Incinerator."

In addition to the Northwest Incinerator, questions have arisen regarding public health implications due to the operation of Philadelphia's East Central Incinerator (ECI). The ECI is located 13 kilometers southeast of the NWI in downtown Philadelphia, on the Delaware river, directly across from Camden, N.J. This incinerator is quite similar in design to the NWI.

In order to address the questions raised, an analysis of ambient concentrations impacts and risk, were performed for both the NWI & ECI. It is important to note, at the outset, that results derived from the ECI analysis are open to question since stack tests for dioxin were conducted only at the NWI.

Given the proximity of the two incinerators, and a desire to define their separate impacts three distinct analyses were performed. They are:

(1) Impact due to the NWI alone,

(2) Impact due to the ECI alone,

(3) Impact due to the combined operation of the two incinerators.

SOURCE DATA

At each of the two facilities there exist two incinerator units each serviced by separate but identical stacks. Since the distance separating the two stacks is small and the exit gas parameters are the same for each unit it was possible to model each facility's total emissions as if they emanated from a single stack.

The total dioxin emissions used in modeling the NWI were provided by David Cleverly. The procedures that were used are fully documented in the previously cited memo. These emissions were derived from the results of a stack test conducted by Midwest Research Institute (MRI) in March, 1985 and from subsequent calculations using the toxic equivalency method.

With regard to the ECI, an assumption was made that the ratio of the emissions from the ECI to the emissions from the NWI would be equal to the ratio of charging rates of the two incinerators. The charging rates of the two facilities were found to be 300 tons/day and 340 tons/day for the ECI and the NWI respectively. Therefore, it was assumed that dioxin emissions from the ECI would be approximately 88% of the emissions from the NWI.

TABLE 1 - SOURCE DATA

Source	Latitude	Longitude	Toxic Equivalent* Emissions (ug/s)	Stack Dia. (m)	Stack Height (m)	Stack Velocity (m/s)	Stack Temp. (°k)	Bldg. Height (m)	Bldg.** Width (m)
Northwest Incinerator	40°02'30"	75°14'40"	4.5	1.83	30.0	33.5	534	11.6	71.5
East Central Incinerator	39°57'40"	75°08'09"	4.0	2.3	31.1	22.1	520	25.0	70.3

* Emissions listed are total for the two units at each facility.

** Since the buildings for both facilities are rectangular, the building width represents the diameter of a circular building of equal horizontal area.

Table 1, presents for each facility, a complete listing of the source parameters and total emissions data used in this study.

An analysis was performed to determine if the dry deposition of dioxin would be significant and thus would need to be accounted for in the modeling analysis. It was assumed that the entire mass of dioxin emitted was adsorbed onto the surface of the particulate matter emission. Then, using a typical particle size distribution for ESP-controlled municipal incinerators a transformation was performed which took the distribution from a weight percent by volume to a weight percent by surface area. This transformation provided a means of estimating how the total mass of dioxin emissions would distribute itself among particle sizes. Then, knowing the percentage of the mass within a particular size range that, upon encountering the ground surface, would reflect, (i.e., eddy reflection coefficient) the maximum percentage of emitted dioxin mass that could dry deposit was estimated. This was determined to be 0.78%. Therefore, for purposes of the air modeling analysis, it was assumed that the dioxin emissions acted as a gas and thus would not dry-deposit as a result of gravitational settling. This above-described analysis is presented, in detail, in Appendix A.

MODEL SELECTION:

In order to determine the most appropriate modeling technique, for any given situation an analysis must be made of the relationship between terrain heights and stack/plume heights. Such an analysis was performed for the area around each incinerator. Major results are presented below:

Northwest Incinerator:

(1) Terrain in most directions achieves stack height at about 500 m from the plant.

(2) There does not exist any terrain within at least 25 km which could be impacted by a stable plume.

(3) Considering the quite typical condition of "D" stability 5.0 m/s wind speed, in general, the terrain rises approximately 50% of the plume's height above stack top.

East Central Incinerator:

(1) Terrain in the entire N.W. quadrant achieves stack height within 5.0 km of the plant.

(2) There exists a piece of terrain 13 km to the N.W. which could be impacted under a condition of "F" stability 2.5 m/s wind speed.

(3) Considering the meteorological condition of "D" stability 5.0 m/s wind speed, terrain in the N.W. quadrant beyond about 7 km, in general, rises approximately 50% of the plume's height above stack top.

Based on the above results, and considering present agency guidance, it was determined that two models were needed in order to appropriately consider the substantial amount of terrain which exists between stack height and plume height. Both a simple and complex terrain model were run on this "in-between" type of terrain. The higher of the two predictions were then used to represent the predicted concentration at each terrain location. This procedure produced hybrid concentration fields which were then provided as input to the HEM model.

In addition to the general type of models needed it is necessary to determine the appropriate modes (urban/rural) for running the models. In order to do this the Auer '78 classification scheme was applied, as required by agency guidance, to the area surrounding each of the two incinerators. For the East Central Incinerator the area was determined to be urban. For the Northwest Incinerator the area was determined to be rural. Therefore, all model runs for the East Central and Northwest incinerators were made using the urban and rural modes of the models respectively.

Considering the above discussion it was determined that the ISCLT & LONGZ models would be most applicable in this study. A brief rationale for their selection is as follows:

ISCLT:

- Can be run in either an urban or rural mode.
- Can account for effects on ground level concentrations produced by building downwash.
- Is capable of considering all terrain heights up to stack top.

LONGZ:-

- Can be run in either an urban or rural mode.
- LONGZ is capable of considering all terrain above stack top.
- Is the only readily available, agency sponsored, complex terrain model which can produce an output that can serve as input to HEM.

A brief description of each of these models can be found in Appendix B.

METEOROLOGY:

Based on data availability and the height of the plume above terrain it was felt that meteorological data taken from the Philadelphia airport's National Weather Service (NWS) station would be representative of the two sites. Since long-term average predictions of concentration are needed for risk assessment purposes, a 17 year joint frequency distribution of the necessary meteorological parameters was used. This data set was chosen since it is the largest set readily available from the Philadelphia airport. Appendix C provides a complete listing of the meteorological data set.

RECEPTOR GRIDS:

Two polar receptor grids were used in the modeling exercise. One centered on the East Central Incinerator and the other centered on the Northwest Incinerator. Each grid was designed to contain 16 radials in order to be consistent with the input requirements of the HEM model. The number and location of the rings for each grid were designed specific to the needs of the analysis of each incinerator. Specific ring placements for each grid are as follows:

East Central Polar Grid (ECG):

This grid contains 13 rings located as follow:

- 0.3 km - downwash considerations.
- 0.78 km, 1.0 km, 1.3 km, 1.8 km, 2.3 km, 3.0 km, 4.1 km, 5.3 km & 7.0 km - based on agency modeling guidance.
- 10.0 km - Chosen to include higher terrain receptors.
- 20.0 km & 50.0 km - chosen to extend the analysis to the limit of modeling capability and thus include the largest possible affected population.

Northwest Polar Grid (NWG):

This grid contains 15 rings located as follows:

- 0.2 km - downwash considerations.
- 0.5 km, 0.65 km, 0.85 km, 1.2 km, 1.5 km, 2.0 km, 2.6 km, 3.4 km & 4.5 km - based on agency modeling guidance.
- 8.0 km, 10.0 km & 12.0 km - chosen to include high population areas.
- 20.0 km & 50.0 km - choosen to extend the analysis to the limit of modeling capability and thus include the largest possible affected population.

MODELING APPROACH:

As was stated previously three distinct analyses were performed. They are:

(I) Impact due to NWI alone

(II) Impact due to ECI alone

(III) Impact due to the combined operation of the two incinerators.

Presented below is the approach which was followed for each of the three analyses.

(I) Northwest Alone:

- This analysis considered only the impacts of the Northwest Incinerator on the N.W. grid.
- The LONGZ & ISCLT models were run separately on the N.W. grid.
- For the ISCLT run, all terrain elevations greater than stack height were modeled at stack height; whereas, for the LONGZ model actual terrain heights were used in the analysis.
- Both models were run in their rural modes.
- Results of the two runs were compared at each receptor and the higher of the two concentrations was assigned to the given receptor.

(II) East Central Alone:

- This analysis considered only the impacts of the East Central Incinerator on the East Central grid.
- The LONGZ & ISCLT models were run separately on the E.C. grid.
- For the ISCLT run, all terrain elevations greater than stack height were modeled at stack height; whereas, for the LONGZ model actual terrain heights were used in the analysis.
- Both models were run in their urban modes.
- Results of the two runs were compared at each receptor and the higher of the two concentrations was assigned to the given receptor.

(III) Combined Impacts:

In order to determine the combined impacts of the two incinerators it was necessary to sum the impacts of the two sources on each of the two grids. The procedure used is as follows:

(A) Combined Impacts - E.C. Grid:

- The Northwest Incinerator was modeled on the E.C. grid with LONGZ & ISCLT separately.
- Terrain was cut-off at stack top to accomplish the ISCLT run.
- Both models were run in their rural modes.
- The highest of the two modeled concentrations at each receptor point was assigned to the given receptor.
- The results of this analysis were added, receptor by receptor, to the results of the analysis for the East Central Incinerator alone. This produced the combined impacts from both incinerators on the E.C. grid.

(B) Combined Impacts - N.W. Grid:

- The East Central Incinerator was modeled on the N.W. grid with LONGZ and ISCLT separately.
- Terrain was cut-off at stack top to accomplish the ISCLT run.
- Both models were run in their urban modes.
- The highest of the two modeled concentrations at each receptor point was assigned to the given receptor.
- The results of this analysis were added, receptor by receptor, to the results of the analysis for the Northwest Incinerator alone. This produced the combined impacts from both incinerators on the N.W. Grid.

In order to determine both individual risk and annual incidence the HEM model was run to evaluate each of the three cases described above. Documentation of the procedures followed, the results determined, and the conclusions formed can be found in the previously mentioned memorandum by David Cleverly.

Results:

A complete listing of the results found in each of the three analyses are presented in Appendix D.

In summary, the highest concentrations found are as follows:

(I) NWI alone - 1.39 (picogms/m^3)

(II) ECI alone - 0.7 (picogms/m^3)

(III) Combined Impacts - 1.4 (picogms/m^3)

cc: D. Barnes (OPTS, DC TS-788)
J. Sydnor (3AM10)
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Appendix A

This appendix presents the analysis performed to determine whether the dry-deposition of dioxin emission could be significant and therefore would need to be accounted for in the air modeling.

The first portion of the analysis is a derivation of the transformation need to convert a volume weight-based particle size distribution to a surface area weight-based particle size distribution. With this transformation a typical volume-based distribution, for ESP controlled municipal incinerators was converted, to a surface-based distribution. The surface-based distribution provides an approximation of how the weight of dioxin is distributed among existing particle sizes. Basic to this approximation is the assumption that the vast majority of the emitted dioxin mass is adsorbed on the surface of the fly-ash particles.

As particles of a particular size approach the ground surface, a portion of these particles could dry-deposit with the complement portion eddy reflecting. The fraction of particles which will reflect is a function of particle size and can be defined by the parameter (γ); the eddy reflection coefficient. A functional relationship between γ and particle size can be found in the ISCLT Users Manual.

Once the distribution has been transformed to a surface area base, the percentage of the weight which resides in each size range can be multiplied by ($1-\gamma$) to determine the maximum amount of dioxin that could dry-deposit from the particular size category. Summing the maximum deposition over each size category produces an estimate of the maximum percentage of emitted dioxin one would expect to dry-deposit.

The detailed results of this analysis are presented in Table Al. Examination of the Table indicates that the maximum weight percent expected to dry-deposit is 0.78%. Therefore it was assumed that the emitted dioxin would act as a gas exhibiting essentially no settling.

The following is a derivation of the previously discussed transformation.

The percentage of the weight of the total distribution of particulates which resides in the i th category ($V_{\%i}$) is given by:

$$V_{\%i} = V_i / V_T$$

where:

$V_{\%i} \equiv$ precentage of weight by volume
$V_i \propto$ Total weight within the i^{th} category
$V_T \propto$ Total weight within the total distribution

If one assumes the particles to be spherical then:

$$V_i = 4/3 \, \pi \, r_i^3 n_i$$

and

$$V_T = 4/3 \, \pi \sum_{i=1}^{N} (r_i^3 n_i)$$

where:

$r_i \equiv$ mass mean radius within the i th particle size category.

$n_i \equiv$ the number of particles which reside within the i th category.

$N \equiv$ the number of size categories

and,

$$V_{\%i} = \frac{r_i^3 n_i}{\sum_{i=1}^{N} (r_i^3 n_i)}$$

let,

$$K = \sum_{i=1}^{N} (r_i^3 n_i)$$ since this term is a constant of the distribution

$$\therefore \quad n_i = \frac{V_{\%i} K}{r_i^3} \qquad (1)$$

If we assume that the mass of interest resides on the surface of the particles then the percentage of the weight of the total distribution which resides in the i^{th} category is given by:

$$S\%_i = S_i / S_T$$

where:

$S\%_i \equiv$ Percentage of weight by surface area

since: $S_i = 4\pi r_i^2 n_i$

$$S_T = 4\pi \sum_{i=1}^{N} (r_i^2 n_i)$$

then:

$$S\%_i = \frac{r_i^2 n_i}{\sum_{i=1}^{N} (r_i^2 n_i)} . \qquad (2)$$

substituting (1) into (2):

$$S\%_i = \frac{V\%_i}{r_i \sum_{i=1}^{N} \left(V\%_i / r_i\right)}$$

This expression allows one to transform a distribution of weight percent by volume to a distribution of weight percent by surface area.

TABLE A1 - MAXIMUM EXPECTED DEPOSITION

SIZE RANGE (u)	MASS MEAN RADIUS (u)	WEIGHT PERCENT BY VOLUME $V\%_i$ x 100 (%)	WEIGHT PERCENT BY SURFACE $S\%_i$ x 100 (%)	FRACTION DEPOSITED (1 - γ)	EXPECTED * WEIGHT PERCENT DEPOSITED (%)
0.7 >	0.7	31	53	0	0
1.0 - 0.7	0.9	24	32	0	0
1.6 - 1.0	1.3	11	10	0	0
3.1 - 1.6	2.5	3	1.4	0	0
4.8 - 3.1	4.0	3	0.9	0.1	0.09
7.0 - 4.8	6.0	1	0.2	0.15	0.03
10.3 - 7.0	8.8	4	0.5	0.21	0.105
16.5 - 10.3	13.7	3	0.3	0.29	0.087
> 16.5	20.0	20	1.2	0.39	0.468
				TOTAL =	0.78%

*(Column 6) = (Column 5) x (Column 4)

APPENDIX B

The following paragraphs provide a brief description of the two models which were used in the study: namely, LONGZ and ISCLT.

LONGZ

The LONGZ computer program is designed to calculate long-term, ground-level pollutant concentrations produced at a large number of receptors by emissions from multiple stack, building and area sources.

LONGZ uses statistical wind summaries to calculate long-term (seasonal, annual or longer) average concentrations. The LONGZ program is applicable primarily to areas of complex terrain; i.e., areas where terrain elevations exceed stack-top elevations.

A summary of the major capabilities of this model follows.

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Reference: Bjorklund, J. R., and J. F. Bowers. "User's Instructions for the SHORTZ and LONGZ Computer Programs. Volumes 1 and 2," EPA 903/9-82-004, U.S. Environmental Protection Agency, Region III, Philadelphia, Pennsylvania 19106, 1982.

Availability: The model is available as part of UNAMAP (Version 6). The computer code is available on magnetic tape from:

Computer Products
National Technical Information Service
U.S. Department of Commerce
Springfield, Virginia 22161

Phone (703) 487-4763

The accession number of the UNAMAP tape is PB

Abstract: LONGZ utilizes the steady-state univariate Gaussian plume formulation for both urban and rural areas in flat or complex terrain to calculate long-term (seasonal and/or annual) ground-level ambient air concentratins attributable to emissions from up to 14,000 arbitrarily placed sources (stacks, buildings and area sources). The output consists of the total concentration at each receptor due to emissions from each user-specified source or group of sources, including all sources. An option which considers losses due to deposition (see the description of SHORTZ) is deemed inappropriate by the authors for complex terrain, and is not discussed here.

Input Requirements

Source data requirements are: for point, building or area, sources, location, elevation, total emission rate (optionally classified by gravitational settling velocity) and decay coefficient; for stack soruces, stack height, effluent temperature, effluent exit velocity, stack radius (inner), emission rate, and ground elevation (optional);

for building sources, height, length and width, and orientation; for area sources, characteristic vertical dimension, and length, width and orientation.

Meteorological data requirements are: wind speed and measurement height, wind profile exponents, wind direction standard deviations (turbulent intensities), mixing height, air temperature, vertical potential temperature gradient.

Receptor data requirements are: coordinates, ground elevation.

Output

Printed output includes:

> Total concentration due to emissions from user-specified source groups, including the combined emissions from all sources (with optional allowance for depletion by deposition).

Type of Model

LONGZ is a climatological Gaussian plume model.

Pollutant Types

LONGZ may be used to model primary pollutants. Settling and deposition are treated.

Source-Receptor Relationships

LONGZ applies user specified locations for sources and receptors.

Receptors are assumed to be at ground level.

Plume Behavior

Plume rise equations of Bjorklund and Bowers (1982) are used.

Stack tip downwash (Bjorklund and Bowers, 1982) is included.

All plumes move horizontally and will fully intercept elevated terrain.

Plumes above mixing height are ignored.

Perfect reflection at mixing height is assumed for plumes below the mixing height.

Plume rise is limited when the mean wind at stack height approaches or exceeds stack exit velocity.

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Perfect reflection at ground is assumed for pollutants with no settling velocity.

Zero reflection at ground is assumed for pollutants with finite settling velocity.

LONGZ does not simulate fumigation.

Tilted plume is used for pollutants with settling velocity specified.

Buoyancy-induced dispersion is treated (Briggs, 1972).

Horizontal Winds

Wind field is homogeneous and steady-state.

Wind speed profile exponents are functions of both stability class and wind speed. Default values are specified in Bjorklund and Bowers (1982).

Vertical Wind Speed

Vertical wind speed is assumed equal to zero.

Horizontal Dispersion

Pollutants are initially uniformly distributed within each wind direction sector. A smoothing function is then used to remove discontinuities at sector boundaries.

Vertical Dispersion

Vertical dispersion is derived from input vertical turbulent intensities using adjustments to plume height and rate of plume growth with downwind distance specified in Bjorklund and Bowers (1982).

Chemical Transformation

Chemical transformations are treated using exponential decay. Time constant is input by the user.

Physical Removal

Gravitational settling and dry deposition of particulates are treated.

Evaluation Studies

Bjorklund, J. R., and J. F. Bowers. "User's Instructions for the SHORTZ and LONGZ Computer Programs," EPA-903/9-82-004, Environmental Protection Agency, Region III, Philadelphia, Pennsylvania 19106, 1982.

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ISCLT

The Industrial Source Complex (ISC) Dispersion Model combines and enhances various dispersion model algorithms into a set of two computer programs that can be used to assess the air quality impact of emissions from the wide variety of sources associated with an industrial source complex. For plumes comprised of particulates with appreciable gravitational settling velocities, the ISC Model accounts for the effects on ambient particulate concentrations of gravitational settling and dry deposition. Alternately, the ISC Model can be used to calculate dry deposition. The ISC long-term model (ISCLT) is a sector-averaged model that extends and combines basic features of the Air Quality Display Model (AQDM) and the Climatological Dispersion Model (CDM). The long-term model uses statistical wind summaries to calculate seasonal (quarterly), annual and/or longer term, ground-level concentration or deposition values.

A summary of the major capabilities of this model follows:

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Reference: Bowers, J. R., J. R. Bjorklund and C. S. Cheney. "Industrial Source Complex (ISC) Dispersion Model User's Guide, Volumes 1 and 2." Publication Nos. EPA-450/4-79-030, 031 (NTIS Numbers: Volume 1, PB-80-133044; Volume 2, PB-80-133051; Magnetic tape, PB-80-133036) Office of Air Quality Planning and Standards, U. S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711, 1979.

Availability: This model is available as part of UNAMAP (Version 6). The computer code is available on magnetic tape from:

Computer Products
National Technical Information Service
U.S. Department of Commerce
Springfield, Virginia 22161

Phone (703) 487-4763

Abstract: The ISC model is a steady-state Gaussian plume model which can be used to access pollutant concentrations from a wide variety of sources associated with an industrial source complex. This model can account for settling and dry deposition of particulates, downwash area, line and volume sources, plume rise as a function of downwind distance, separation of point sources, and limited terrain adjustment. It operates in both long- and short-term modes.

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Input Requirements

Source data requirements are: location, emission rate, pollutant decay coefficient, elevation of source, stack height, stack exit velocity, stack inside diameter, stack exit temperature, particle size distribution with corresponding settling velocities, surface reflection coefficient, and dimensions of adjacent buildings.

Meteorological data requirements are: for short term modeling, hourly surface weather data from the EPA meteorological preprocessor program. Preprocessor output includes hourly stability class, wind direction, wind speed, temperature, and mixing height. For long-term modeling, stability wind rose (STAR deck), average afternoon mixing height, average morning mixing height, and average air temperature.

Receptor data requirements are: coordinates of each receptor.

Output

Printed output options include:

- program control parameters, source data and receptor data;
- tables of hourly meteorological data for each specified day;
- "N"-day average concentration or total deposition calculated at each receptor for any desired combinations of sources;
- concentration or deposition values calculated for any desired combinations of sources at all receptors for any specified day or time period within the day;
- tables of highest and second-highest concentration or deposition values calculated at each receptor for each receptor for each specified time period during an "N"-day period for any desired combinations of sources; and
- tables of the maximum 50 concentration or deposition values calculated for any desired combinations of sources for each specified time period.

Type of Model

ISC is a Gaussian plume model.

Pollutant Types

ISC may be used to model primary pollutants. Settling and deposition are treated.

Source-Receptor Relationships

ISC applies user-specified locations for point, line, area and volume sources, and user-specified receptor locations or receptor rings.

Receptors are assumed to be at ground level, and must be at elevations not exceeding stack height.

Actual separation between each source-receptor pair is used.

Plume Behavior

ISC uses Briggs (1971, 1972) plume rise equations for final rise.

Stack tip downwash (Bjorklund and Bowers, 1982) and building downwash (Huber and Snyder, 1976) are used.

For rolling terrain (terrain not above stack height), plume centerline is horizontal at height of final rise above source.

Fumigation is not treated.

Horizontal Winds

Constant, uniform (steady-state) wind is assumed for an each hour.

Straight line plume transport is assumed to all downwind distances.

Separate wind speed profile exponents (Irwin, 1979) for both rural and urban cases are used.

Vertical Wind Speed

Vertical wind speed is assumed equal to zero.

Horizontal Dispersion

Rural dispersion coefficients from Turner (1969) are used, with no adjustments for surface roughness or averaging time.

Urban dispersion coefficients from McElroy and Pooler (1968), as formulated by Briggs (1974) are used.

Buoyancy induced dispersion (Pasquill, 1976) is included.

Six stability classes are used, with Turner class 7 treated as class 6.

Vertical Dispersion

Rural dispersion coefficients from Turner (1969) are used, with no adjustments for surface roughness.

Urban dispersion coefficients from McElroy and Pooler (1969), as formulated by Briggs (1974) are used.

Buoyancy induced dispersion (Pasquill, 1976) is included.

Six stability classes are used, with Turner class 7 treated as class 6.

Mixing height is accounted for with multiple reflections until the vertical coefficient equals 1.6 times the mixing height; uniform vertical mixing is assumed beyond that point.

Perfect reflection is assumed at the ground.

Chemical Transformation

Chemical transformations are treated using exponential decay. Time constant is input by the user.

Physical Removal

Settling and dry deposition of particulates are treated.

Evaluation Studies

Bowers, J. F., and A. J. Anderson. "An Evaluation Study for the Industrial Source Complex (ISC) Dispersion Model," EPA-450/4-81-002, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711, 1981.

Bowers, J. F., A. J. Anderson, and W. R. Hargraves. "Tests of the Industrial Source Complex (ISC) Dispersion Model at the Armco Middletown, Ohio Steel Mill," EPA-450/4-82-006 (NTIS PB 82-257-312), U. S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711, 1982.

Scire, J. S., and L. L. Schulman. "Evaluation of the BLP and ISC Models with SF6 Tracer Data and SO2 Measurements at Aluminum Reduction Plants," APCA Specialty Conference on Dispersion Modeling for Complex Sources, 1981.

APPENDIX C

The following series of tables provides a complete list of meteorological data which was input to the models.

METEOROLOGICAL INPUT DATA

AMBIENT AIR TEMPERATURE (DEGREES KELVIN)

STABILITY CATEGORY 1	STABILITY CATEGORY 2	STABILITY CATEGORY 3	STABILITY CATEGORY 4	STABILITY CATEGORY 5	STABILITY CATEGORY 6
286.0000	286.0000	286.0000	286.0000	286.0000	286.0000

MIXING LAYER HEIGHT (METERS)

	WIND SPEED CATEGORY 1	WIND SPEED CATEGORY 2	WIND SPEED CATEGORY 3	WIND SPEED CATEGORY 4	WIND SPEED CATEGORY 5	WIND SPEED CATEGORY 6
STABILITY CATEGORY 1	.180000+004	.180000+004	.180000+004	.180000+004	.180000+004	.180000+004
STABILITY CATEGORY 2	.160000+004	.160000+004	.160000+004	.160000+004	.160000+004	.160000+004
STABILITY CATEGORY 3	.140000+004	.140000+004	.140000+004	.140000+004	.140000+004	.140000+004
STABILITY CATEGORY 4	.100000+004	.100000+004	.100000+004	.100000+004	.100000+004	.100000+004
STABILITY CATEGORY 5	.100000+005	.100000+005	.100000+005	.100000+005	.100000+005	.100000+005
STABILITY CATEGORY 6	.100000+005	.100000+005	.100000+005	.100000+005	.100000+005	.100000+005

FREQUENCY OF OCCURRENCE OF WIND SPEED, DIRECTION AND STABILITY

STABILITY CATEGORY 1

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (.7500MPS)	WIND SPEED CATEGORY 2 (2.5000MPS)	WIND SPEED CATEGORY 3 (4.3000MPS)	WIND SPEED CATEGORY 4 (6.8000MPS)	WIND SPEED CATEGORY 5 (9.5000MPS)	WIND SPEED CATEGORY 6 (12.5000MPS)
.000	.00004499	.00016197	.00000000	.00000000	.00000000	.00000000
22.500	.00002900	.00006799	.00000000	.00000000	.00000000	.00000000
45.000	.00003399	.00004699	.00000000	.00000000	.00000000	.00000000
67.500	.00003000	.00008099	.00000000	.00000000	.00000000	.00000000
90.000	.00008899	.00015498	.00000000	.00000000	.00000000	.00000000
112.500	.00003599	.00022196	.00000000	.00000000	.00000000	.00000000
135.000	.00009099	.00017497	.00000000	.00000000	.00000000	.00000000
157.500	.00010798	.00020897	.00000000	.00000000	.00000000	.00000000
180.000	.00013398	.00032295	.00000000	.00000000	.00000000	.00000000
202.500	.00008499	.00026896	.00000000	.00000000	.00000000	.00000000
225.000	.00015797	.00041693	.00000000	.00000000	.00000000	.00000000
247.500	.00013198	.00037594	.00000000	.00000000	.00000000	.00000000
270.000	.00007299	.00029595	.00000000	.00000000	.00000000	.00000000
292.500	.00004699	.00010798	.00000000	.00000000	.00000000	.00000000
315.000	.00007499	.00016797	.00000000	.00000000	.00000000	.00000000
337.500	.00005099	.00014098	.00000000	.00000000	.00000000	.00000000

STABILITY CATEGORY 2

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (.7500MPS)	WIND SPEED CATEGORY 2 (2.5000MPS)	WIND SPEED CATEGORY 3 (4.3000MPS)	WIND SPEED CATEGORY 4 (6.8000MPS)	WIND SPEED CATEGORY 5 (9.5000MPS)	WIND SPEED CATEGORY 6 (12.5000MPS)
.000	.00060090	.00125880	.00125980	.00000000	.00000000	.00000000
22.500	.00016097	.00039594	.00030895	.00000000	.00000000	.00000000
45.000	.00023696	.00040294	.00028895	.00000000	.00000000	.00000000
67.500	.00018697	.00061090	.00039594	.00000000	.00000000	.00000000
90.000	.00060090	.00126180	.00091985	.00000000	.00000000	.00000000
112.500	.00046892	.00122880	.00052392	.00000000	.00000000	.00000000
135.000	.00049692	.00122180	.00052392	.00000000	.00000000	.00000000
157.500	.00053191	.00098684	.00046393	.00000000	.00000000	.00000000
180.000	.00084686	.00151676	.00069789	.00000000	.00000000	.00000000
202.500	.00053191	.00128179	.00115481	.00000000	.00000000	.00000000
225.000	.00072188	.00291253	.00344245	.00000000	.00000000	.00000000
247.500	.00072088	.00255059	.00240261	.00000000	.00000000	.00000000
270.000	.00095185	.00186570	.00151076	.00000000	.00000000	.00000000
292.500	.00047692	.00125880	.00084586	.00000000	.00000000	.00000000
315.000	.00048392	.00124880	.00106783	.00000000	.00000000	.00000000
337.500	.00037094	.00114082	.00089986	.00000000	.00000000	.00000000

STABILITY CATEGORY 3

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (.7500MPS)	WIND SPEED CATEGORY 2 (2.5000MPS)	WIND SPEED CATEGORY 3 (4.3000MPS)	WIND SPEED CATEGORY 4 (6.8000MPS)	WIND SPEED CATEGORY 5 (9.5000MPS)	WIND SPEED CATEGORY 6 (12.5000MPS)
.000	.00035594	.00196668	.00543613	.00107383	.00002100	.00000000
22.500	.00013498	.00063090	.00150376	.00020897	.00000700	.00000000
45.000	.00012098	.00063090	.00110082	.00020897	.00000000	.00000000
67.500	.00013598	.00067189	.00224164	.00030895	.00002100	.00000000
90.000	.00034594	.00157075	.00355643	.00042293	.00000700	.00000000
112.500	.00036294	.00118781	.00134878	.00006799	.00000000	.00000000
135.000	.00039394	.00105383	.00117481	.00014798	.00000000	.00000000
157.500	.00044893	.00104683	.00122880	.00012098	.00000000	.00000000
180.000	.00052991	.00148976	.00240261	.00032895	.00000000	.00000000
202.500	.00036094	.00109382	.00267757	.00059790	.00000700	.00000000
225.000	.00055291	.00365741	.01089825	.00196668	.00010798	.00000000
247.500	.00051892	.00316749	.00881758	.00138978	.00002100	.00000000
270.000	.00066789	.00253059	.00542213	.00102684	.00005399	.00000700
292.500	.00039894	.00125580	.00424132	.00116181	.00006099	.00001400
315.000	.00032195	.00144977	.00478523	.00140277	.00008099	.00000700
337.500	.00027096	.00133579	.00410734	.00098684	.00004099	.00000700

STABILITY CATEGORY 4

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (.7500MPS)	WIND SPEED CATEGORY 2 (2.5000MPS)	WIND SPEED CATEGORY 3 (4.3000MPS)	WIND SPEED CATEGORY 4 (6.8000MPS)	WIND SPEED CATEGORY 5 (9.5000MPS)	WIND SPEED CATEGORY 6 (12.5000MPS)
.000	.00088586	.00620700	.01709826	.01828606	.00173172	.00011498
22.500	.00039594	.00173872	.00673092	.00779775	.00094685	.00014098
45.000	.00047692	.00261058	.00834166	.00918653	.00149676	.00022896
67.500	.00077488	.00526116	.01794312	.01639337	.00240261	.00031595
90.000	.00174472	.00940849	.01859402	.01043532	.00122180	.00012798
112.500	.00157875	.00724784	.00724084	.00222864	.00013498	.00004099
135.000	.00165473	.00628799	.00670392	.00228863	.00017497	.00000700
157.500	.00148276	.00585206	.00722784	.00339545	.00046992	.00002700
180.000	.00186070	.00648896	.01620540	.01166313	.00111482	.00023496
202.500	.00088086	.00342245	.00971044	.00751579	.00069189	.00008099
225.000	.00122780	.00800571	.02680070	.01677631	.00151076	.00016197
247.500	.00120081	.00661694	.01331986	.00909954	.00068489	.00024196
270.000	.00153175	.00658294	.01382378	.02144656	.00481123	.00153675
292.500	.00087786	.00357743	.01101223	.02711665	.00827467	.00186570
315.000	.00078487	.00322148	.01060930	.02780054	.00724084	.00132879
337.500	.00060590	.00347644	.00853563	.01662133	.00274456	.00040993

STABILITY CATEGORY 5

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (.7500MPS)	WIND SPEED CATEGORY 2 (2.5000MPS)	WIND SPEED CATEGORY 3 (4.3000MPS)	WIND SPEED CATEGORY 4 (6.8000MPS)	WIND SPEED CATEGORY 5 (9.5000MPS)	WIND SPEED CATEGORY 6 (12.5000MPS)
.000	.00000000	.00438230	.01138117	.00000000	.00000000	.00000000
22.500	.00000000	.00085956	.00258359	.00000000	.00000000	.00000000
45.000	.00000000	.00112782	.00117481	.00000000	.00000000	.00000000
67.500	.00000000	.00202068	.00181271	.00000000	.00000000	.00000000
90.000	.00000000	.00371140	.00158375	.00000000	.00000000	.00000000
112.500	.00000000	.00314749	.00068489	.00000000	.00000000	.00000000
135.000	.00000000	.00344945	.00090685	.00000000	.00000000	.00000000
157.500	.00000000	.00425432	.00124180	.00000000	.00000000	.00000000
180.000	.00000000	.00666393	.00497920	.00000000	.00000000	.00000000
202.500	.00000000	.00361042	.00397936	.00000000	.00000000	.00000000
225.000	.00000000	.00885158	.01177011	.00000000	.00000000	.00000000
247.500	.00000000	.00648896	.00513418	.00000000	.00000000	.00000000
270.000	.00000000	.00689189	.01415873	.00000000	.00000000	.00000000
292.500	.00000000	.00401336	.01155515	.00000000	.00000000	.00000000
315.000	.00000000	.00268457	.00837466	.00000000	.00000000	.00000000
337.500	.00000000	.00289254	.00591205	.00000000	.00000000	.00000000

STABILITY CATEGORY 6

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (.7500MPS)	WIND SPEED CATEGORY 2 (2.5000MPS)	WIND SPEED CATEGORY 3 (4.3000MPS)	WIND SPEED CATEGORY 4 (6.8000MPS)	WIND SPEED CATEGORY 5 (9.5000MPS)	WIND SPEED CATEGORY 6 (12.5000MPS)
.000	.00303451	.00989141	.00000000	.00000000	.00000000	.00000000
22.500	.00099684	.00167773	.00000000	.00000000	.00000000	.00000000
45.000	.00100984	.00104683	.00000000	.00000000	.00000000	.00000000
67.500	.00109982	.00140977	.00000000	.00000000	.00000000	.00000000
90.000	.00199068	.00230863	.00000000	.00000000	.00000000	.00000000
112.500	.00180371	.00190669	.00000000	.00000000	.00000000	.00000000
135.000	.00222164	.00202068	.00000000	.00000000	.00000000	.00000000
157.500	.00263158	.00292653	.00000000	.00000000	.00000000	.00000000
180.000	.00448928	.00589905	.00000000	.00000000	.00000000	.00000000
202.500	.00277455	.00402035	.00000000	.00000000	.00000000	.00000000
225.000	.00441929	.01176311	.00000000	.00000000	.00000000	.00000000
247.500	.00544413	.01071628	.00000000	.00000000	.00000000	.00000000
270.000	.00691089	.01596444	.00000000	.00000000	.00000000	.00000000
292.500	.00313650	.00809270	.00000000	.00000000	.00000000	.00000000
315.000	.00280755	.00630099	.00000000	.00000000	.00000000	.00000000
337.500	.00246260	.00590505	.00000000	.00000000	.00000000	.00000000

Appendix D

The following Tables present the result of the concentration predictions for each of the three analyses. For the combined impacts analysis there are two tables since the combined impacts were modeled on each of the two grids.

IMPACT FROM NORTHWEST INCINERATOR ALONE

CONCENTRATIONS IN UG/M3

	.200 Km	.500	.650	.850	1.200	1.500	2.000	2.600	3.400	4.500
S	1.3519-012	3.1298-009	7.8687-009	2.4638-008	1.1008-007	3.2321-007	4.3398-007	2.7581-007	2.3383-007	1.4856-007
SSW	6.7120-013	5.6876-010	2.0861-009	4.9281-008	1.2099-007	8.1771-008	1.6262-007	9.7030-008	6.9587-008	4.4144-008
SW	6.0570-013	4.7891-010	1.8598-009	1.3021-007	2.7820-007	2.9291-007	1.9992-007	1.2550-007	8.1923-008	4.9862-008
WSW	1.3645-012	1.6257-009	3.0912-009	1.1437-007	2.9573-007	3.4102-007	2.9728-007	1.8352-007	1.3326-007	8.2822-008
W	1.0896-011	8.9136-009	5.8778-009	2.0523-008	3.8256-007	4.1648-007	2.0886-007	2.2532-007	1.6921-007	1.1135-007
WNW	2.9799-011	5.6711-009	1.2630-008	1.4667-008	3.1953-008	4.8577-008	1.0809-007	1.0547-007	9.1700-008	6.7140-008
NW	1.4061-010	6.5717-008	9.4536-008	4.7662-008	2.2626-007	1.7880-007	1.7673-007	1.1021-007	6.8407-008	4.7269-008
NNW	5.7808-010	1.2478-007	2.5066-007	1.8636-007	1.9055-007	2.1949-007	2.7122-007	1.6579-007	9.8062-008	6.6182-008
N	8.4867-011	1.4137-007	4.1900-007	9.5419-007	7.5124-007	7.9876-007	5.5159-007	3.6192-007	2.1366-007	1.1585-007
NNE	2.6969-010	1.8213-007	3.0170-007	5.2998-007	4.9400-007	4.1204-007	3.0191-007	1.9911-007	1.0853-007	8.7266-008
NE	6.6144-010	4.8433-007	8.0194-007	1.3982-006	9.9451-007	9.5918-007	7.0881-007	3.6854-007	3.3334-007	2.1345-007
ENE	1.6983-010	3.1613-007	5.1274-007	8.0010-007	6.4257-007	3.9357-007	4.1010-007	2.8484-007	2.3797-007	1.6039-007
E	1.9587-010	1.3946-007	4.5251-007	6.0224-007	8.8395-007	4.9400-007	4.6170-007	2.8812-007	3.0155-007	1.9711-007
ESE	1.2657-010	3.6189-008	3.4028-007	2.6462-007	6.9970-007	5.1933-007	4.6134-007	3.0431-007	2.0059-007	1.3296-007
SE	7.7934-012	1.1282-008	1.2730-007	1.9968-007	3.0597-007	2.7973-007	2.6269-007	2.0958-007	1.5716-007	9.4341-008
SSE	2.4147-012	8.4890-009	1.1843-008	2.2576-008	6.1954-008	8.6781-008	1.2626-007	1.7625-007	1.4400-007	9.8774-008

	8.000	10.000	12.000	20.000	50.000
S	4.9219-008	4.3358-008	3.8358-008	2.5420-008	1.0519-008
SSW	1.6233-008	1.3886-008	1.2001-008	7.5110-009	2.9103-009
SW	2.4995-008	2.0433-008	1.6388-008	9.6757-009	2.9636-009
WSW	4.5647-008	2.7958-008	2.8145-008	1.7652-008	5.9191-009
W	4.8914-008	4.1153-008	3.5198-008	2.1379-008	7.8251-009
WNW	2.4997-008	1.5241-008	1.3328-008	9.4339-009	5.2045-009
NW	2.2067-008	1.4726-008	1.3227-008	9.4642-009	5.4984-009
NNW	2.5366-008	2.5697-008	2.2882-008	1.4748-008	6.4949-009
N	4.5290-008	3.9200-008	3.0824-008	2.9726-008	1.1921-008
NNE	2.9246-008	2.3051-008	1.9675-008	1.7124-008	7.5274-009
NE	9.7119-008	8.2564-008	7.1341-008	3.7612-008	1.7997-008
ENE	5.7395-008	3.7245-008	3.4253-008	2.3027-008	1.0664-008
E	7.1809-008	5.2903-008	4.7459-008	3.2973-008	1.4890-008
ESE	5.3068-008	4.5300-008	3.9238-008	2.4900-008	9.9335-009
SE	4.8550-008	4.0807-008	3.4960-008	2.1665-008	8.4639-009
SSE	3.3746-008	2.9040-008	2.5340-008	1.6431-008	6.7857-009

IMPACT FROM EAST CENTRAL INCINERATOR ALONE
CONCENTRATIONS IN UG/M3

	.300 Km	.780	1.000	1.300	1.800	2.300	3.000	4.100	5.300	7.000
S	3.3907-008	4.7223-007	5.0881-007	4.7291-007	3.6081-007	2.6626-007	1.7897-007	1.0563-007	6.6394-008	4.5216-008
SSW	1.0691-008	1.7289-007	1.7761-007	1.5671-007	1.1395-007	8.2182-008	5.4391-008	3.1774-008	1.9878-008	1.5413-008
SW	1.1841-008	2.1382-007	2.1113-007	1.7941-007	1.2601-007	8.9316-008	5.8392-008	3.3816-008	2.1069-008	1.6894-008
WSW	1.8941-008	3.9489-007	3.8943-007	3.3914-007	2.3134-007	1.6117-007	1.0389-007	5.9220-008	3.6876-008	3.5298-008
W	2.2448-008	3.9495-007	4.1479-007	3.6991-007	2.7583-007	1.9758-007	1.3008-007	7.5699-008	4.8047-008	3.9310-008
WNW	1.0170-008	1.7598-007	2.0316-007	2.0471-007	1.6330-007	1.2404-007	8.3335-008	4.8289-008	2.9939-008	1.7847-008
NW	1.0410-008	1.5680-007	1.8620-007	1.9334-007	1.6117-007	1.2474-007	8.4449-008	4.9235-008	3.0963-008	1.8108-008
NNW	1.0345-008	1.7180-007	2.0318-007	2.1179-007	1.7355-007	1.3228-007	9.2328-008	5.4793-008	3.4482-008	2.0661-008
N	2.0147-008	3.6397-007	4.0786-007	3.9411-007	3.1519-007	2.3817-007	1.6121-007	9.8169-008	6.1472-008	4.2532-008
NNE	2.3340-008	2.5131-007	2.7179-007	2.5460-007	1.9802-007	1.4755-007	1.0014-007	6.0283-008	3.8469-008	2.8015-008
NE	6.7684-008	6.6127-007	7.0460-007	6.4978-007	4.9386-007	3.6432-007	2.4504-007	1.4477-007	9.1066-008	5.9223-008
ENE	4.7364-008	4.3533-007	4.7117-007	4.4574-007	3.4955-007	2.6286-007	1.7963-007	1.0753-007	6.8147-008	4.0793-008
E	4.8674-008	5.6467-007	6.1622-007	5.8992-007	4.6696-007	3.5225-007	2.4102-007	1.4431-007	9.2819-008	6.0305-008
ESE	4.8624-008	5.4833-007	5.4820-007	4.8391-007	3.5663-007	2.5965-007	1.7312-007	1.0167-007	6.3771-008	5.0907-008
SE	4.9426-008	5.3886-007	5.2590-007	4.5187-007	3.2465-007	2.3345-007	1.5432-007	9.0102-008	5.6770-008	4.6237-008
SSE	3.0608-008	3.5897-007	3.6556-007	3.2649-007	2.4274-007	1.7753-007	1.1879-007	6.9966-008	4.3958-008	3.1589-008

	10.000	20.000	50.000
S	3.5247-008	1.9598-008	6.4508-009
SSW	1.1590-008	6.0428-009	1.9269-009
SW	1.2693-008	6.2012-009	2.0091-009
WSW	2.5832-008	1.2642-008	3.8771-009
W	2.9208-008	1.4447-008	4.6467-009
WNW	1.4664-008	7.6808-009	2.6725-009
NW	1.2889-008	7.4298-009	2.6111-009
NNW	1.6158-008	8.3955-009	2.9199-009
N	3.3606-008	1.6303-008	5.380[illegible]
NNE	2.1658-008	1.0306-008	3.3799-009
NE	4.8250-008	2.5827-008	8.6620-009
ENE	2.8620-008	1.6120-008	5.8670-009
E	4.4046-008	2.3125-008	8.0015-009
ESE	3.6838-008	1.9933-008	6.0951-009
SE	3.7354-008	1.7735-008	5.3815-009
SSE	2.4199-008	1.3176-008	4.1352-009

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COMBINED IMPACTS ON EAST CENTRAL GRID
CONCENTRATIONS IN UG/M3

	.300 Km	.780	1.000	1.300	1.800	2.300	3.000	4.100	5.300	7.000
S	6.6020-008	5.0302-007	5.3903-007	5.0237-007	3.8907-007	2.9340-007	2.0467-007	1.2928-007	8.8081-008	6.4566-008
SSW	4.2885-008	2.0385-007	2.0802-007	1.8639-007	1.4245-007	1.0955-007	8.0263-008	5.5492-008	4.1482-008	3.5260-008
SW	4.4235-008	2.4525-007	2.4211-007	2.0978-007	1.5534-007	1.1761-007	8.5238-008	5.8436-008	4.4399-008	4.2303-008
WSW	5.1629-008	4.2705-007	4.2132-007	3.7055-007	2.6215-007	1.9121-007	1.3274-007	8.5996-008	6.4440-008	6.7129-008
W	5.5484-008	4.2801-007	4.4785-007	4.0293-007	3.0871-007	2.3022-007	1.6221-007	1.0655-007	7.8642-008	7.7254-008
WNW	4.3553-008	2.0999-007	2.3746-007	2.3939-007	1.9860-007	1.5993-007	1.1994-007	8.5667-008	6.7361-008	6.2647-008
NW	4.4082-008	1.9163-007	2.2158-007	2.2951-007	1.9871-007	1.6376-007	1.2571-007	9.4455-008	8.1229-008	8.6589-008
NNW	4.4198-008	2.0705-007	2.3903-007	2.4848-007	2.1170-007	1.7199-007	1.3439-007	1.0092-007	8.5655-008	8.8766-008
N	5.4041-008	3.9898-007	4.4339-007	4.3034-007	3.5264-007	2.7687-007	2.0171-007	1.4160-007	1.0815-007	9.3869-008
NNE	5.7086-008	2.8582-007	3.0664-007	2.8992-007	2.3412-007	1.8440-007	1.3800-007	9.9603-008	7.9237-008	7.1171-008
NE	1.0118-007	6.9510-007	7.3857-007	6.8394-007	5.2830-007	3.9900-007	2.7999-007	1.7998-007	1.2633-007	9.5071-008
ENE	8.0576-008	4.6843-007	5.0421-007	4.7869-007	3.8233-007	2.9545-007	2.1192-007	1.3925-007	9.9130-008	7.0545-008
E	8.1584-008	5.9709-007	6.4841-007	6.2179-007	4.9830-007	3.8307-007	2.7112-007	1.7327-007	1.2055-007	8.6384-008
ESE	8.1209-008	5.8022-007	5.7972-007	5.1494-007	3.8687-007	2.8913-007	2.0158-007	1.2862-007	8.9223-008	7.4474-008
SE	8.1749-008	5.7017-007	5.5677-007	4.8216-007	3.5401-007	2.6193-007	1.8161-007	1.1568-007	8.0700-008	6.8143-008
SSE	6.2766-008	3.8989-007	3.9594-007	3.5616-007	2.7130-007	2.0506-007	1.4497-007	3.4235-008	6.6419-008	5.1890-008

	10.000	20.000	50.000
S	5.1418-008	3.2260-008	1.4069-008
SSW	3.1883-008	2.4254-008	8.0695-009
SW	4.0270-008	1.8938-008	4.8341-009
WSW	5.9819-008	2.0562-008	7.8977-009
W	6.4049-008	2.8953-008	1.2911-008
WNW	1.0606-007	4.7870-008	1.0665-008
NW	1.7615-007	3.3246-008	9.9605-009
NNW	1.8568-007	3.9675-008	1.3541-008
N	8.9811-008	6.8344-008	1.6877-008
NNE	6.7318-008	3.8042-008	1.8825-008
NE	8.4690-008	4.9950-008	2.0313-008
ENE	5.7265-008	4.0725-008	1.7547-008
E	6.7501-008	4.1246-008	1.8968-008
ESE	5.7631-008	3.4741-008	1.3825-008
SE	5.6380-008	3.0882-008	1.2046-008
SSE	4.1525-008	2.4771-008	9.8527-009

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

10 JAN 1986

MEMORANDUM

SUBJECT: Risk Assessment of Emissions of CDDs/CDFs from the Philadelphia Northwest Municipal Incinerator

FROM: David H. Cleverly, Environmental Scientist
Pollutant Assessment Branch, SASD

David H. Cleverly

TO: Donald Barnes
Chairperson/Chlorinated Dioxin Workgroup

W. Ray Cunningham, Director
Air Management Division, Region III

On January 3, 1986, the Chlorinated Dioxin Work Group (CDWG) reviewed and approved the preliminary risk assessment of emissions of CDDs/CDFs from the Philadelphia NW municipal incinerator. The following is a synopsis of the risk assessment methodology used in estimating the risks. The contractor, MRI, was able to resolve the speciation of 2,3,7,8-chlorine substituted compounds within each homologue group, thus providing a unique application of the toxic equivalence method in risk assessment.

Description of City of Philadelphia Northwest Incinerator

The City of Philadelphia Northwest Incinerator plant operates two refuse furnaces which can each process up to 375 tons of trash per day. The operation of the units is designed to achieve a 90% volume reduction in refuse. Each furnace consists of a single (primary) excess air combustion chamber with air cooled walls. Exhausts from each furnace pass through cooling sprays, two evaporation towers, a two-stage (field) ESP, and the stack. Figure 1 is a schematic of the northwest incinerator furnace.

An elevated crane with a clam-shell bucket lifts the refuse from the storage bin into a charging hopper and water-cooled gravity chute. Refuse drops from the chute onto the inclined traveling grate, which continuously feeds the refuse onto a horizontal traveling grate. Each grate is driven by independent variable speed motors. The total effective grate area provided by the two grates is 480 ft^2 per furnace. Combustion air (taken from outside the building) is provided to each furnace by a 50 HP forced draft fan. The underfire/overfire air ratio is adjusted by dampers in the forced draft ductwork. The refractory lined furnaces are designed to operate at a maximum temperature of 2100°F.

Incinerator residues drop off the edge of the horizontal grate and fall through a series of residue-quenching sprays and onto a submerged

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Air Management [illegible]

residue conveyor. The ESP fly ash also is discharged onto the submerged residue conveyor. Residue is discharged into trucks.

Furnace flue gases exit the furnaces through spray chambers where air-atomized water cools the gases to the designed ESP operating temperature. The cooling water evaporates in the two evaporation towers so that flue gases entering the ESP are between 550° and 600°F. The cyclonic flow in the two towers is also designed to remove the largest particles from the flue gases prior to their entry into the ESP.

Flue gases leave the towers and travel through the precipitator breeching where turning vanes and baffle plates ensure even gas distribution throughout the device. Treated flue gases are drawn from each precipitator by an induced draft variable speed fan and exit the plant through a single stack.

Risk Assessment Methodology

Stack tests for PCDD/PCDF emissions were completed for both the Unit 1 furnace and Unit 2 furnace in March, 1985. Tables 8 and 10 (copied from the MRI test report) report the homologue specific and isomer specific analysis of emissions from Unit 1. Tables 9 and 11 report the same analysis for Unit 2.

The risk assessment procedure utilized the method discussed in Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-Dioxins and Dibenzofurans (CDDs and CDFs), October 1985, initially produced by the CDWG and reviewed and endorsed by the Risk Assessment Forum. In general, an assessment of the risk to human health of mixture of CDDs and CDFs, using the TEF approach, involves the following steps:

1. Analytical determination of the CDDs and CDFs in the sample.
2. Multiplication of congener concentrations in the sample by the toxic equivalence factors (TEFs) in Table I to express the concentration in terms of 2378-TCDD equivalents.
3. Summation of the products in step 2 to obtain the total 2378-TCDD equivalents in the sample.
4. Determination of human exposure to the mixture in question, expressed in terms of equivalents of 2,3,7,8-TCDD.
5. Combination of exposure from step 4 with the carcinogenicity potency estimate for 2378-TCDD to estimate risks associated with the mixture. In this case in which the concentrations of the fifteen congeners of concern are known:

2378-TCDD Equivalents = sum of: (TEF of each 2378-CDD/CDF congener x the concentration of the respective congener) + (TEF of each non-2378 CDD/CDF congener x the concentration of the respective congener)

TABLE I

CDD/CDF ISOMERS OF MOST TOXIC CONCERN[a]

DIOXIN		DIBENZOFURAN	
Isomer	TEF[b]	Isomer	TEF
2,3,7,8-TCDD	1	2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDD	0.5	1,2,3,7,8-PeCDF	0.1
		2,3,4,7,8-PeCDF	0.1
1,2,3,4,7,8-HxCDD	0.04	1,2,3,4,7,8-HxCDF	0.01
1,2,3,7,8,9-HxCDD	0.04	1,2,3,7,8,9-HxCDF	0.01
1,2,3,6,7,8-HxCDD	0.04	1,2,3,6,7,8-HxCDF	0.01
		2,3,4,6,7,8-HxCDF	0.01
1,2,3,4,6,7,8-HpCDD	0.001	1,2,3,4,6,7,8-HpCDF	0.001
		1,2,3,4,7,8,9-HpCDF	0.001

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a/ In each homologous group the relative toxicity factor for the isomers not listed above is 1/100 of the value listed above.

b/ TEF = toxic equivalence factor = relative toxicity assigned.

TABLE 3

CALCULATION OF STACK EMISSION RATE (MICROGRAMS/SECOND) OF 2378-TCDD EQUIVALENT CONCENTRATION OF CDDs/CDFs DURING THE OPERATION OF UNIT 2

Congener	TEF	Test 1A	TCDD Equiv	Test 2A	TCDD Equiv	Test 3B	TCDD Equiv
2378-TCDD	1	0.14	0.140	0.28	0.280	0.17	0.170
Other TCDDs	.01	4.26	0.043	8.62	0.086	3.83	0.038
1,2,3,7,8-PeCDD	.5	1.10	0.550	2.20	1.100	1.10	0.550
Other PeCDDs	.005	8.90	0.045	22.80	0.114	12.90	0.066
1,2,3,4,7,8-HxCDD	.04	2.50	0.100	1.40	0.056	1.50	0.060
*1,2,3,7,8,9-HxCDD	.04	2.50	0.100	1.40	0.056	1.50	0.060
*1,2,3,7,8-HxCDD	.04	2.50	0.100	1.40	0.056	1.50	0.060
Other HxCDDs	.0004	10.50	0.004	7.80	0.003	8.50	0.003
1,2,3,4,6,7,8-HpCDD	.001	3.30	0.003	2.80	0.003	3.40	0.003
Other HpCDD	.00001	**	**	**	**	**	**
2378-TCDF	.1	0.35	0.035	0.76	0.076	0.52	0.052
Other TCDFs	.001	6.55	0.007	17.24	0.017	10.48	0.011
1,2,3,7,8-PeCDF	.1	0.39	0.039	2.40	0.240	1.05	0.105*
2,3,4,7,8-PeCDF	.1	0.52	0.052	2.40	0.240	2.10	0.210
Other PeCDFs	.001	9.09	0.009	19.20	0.019	11.50	0.012
1,2,3,4,7,8-HxCDF	.01	2.50	0.025	1.60	0.016	1.20	0.012***
*1,2,3,7,8,9-HxCDF	.01	1.38	0.013	1.60	0.016	1.90	0.019
1,2,3,6,7,8-HxCDF	.01	0.25	0.003	1.60	0.016	2.60	0.026
*2,3,4,6,7,8-HxCDF	.01	1.38	0.013	1.60	0.016	1.90	0.019
Other HxCDFs	.0001	12.49	0.001	**	**	**	**
1,2,3,4,6,7,8-HpCDF	.001	4.40	0.004	**	**	2.3	0.002
1,2,3,4,7,8,9-HpCDF	.001	0.35	**	0.48	0.001	**	**
Other HpCDFs	.00001	**	**	**	**	**	**
2378-TCDD Equivalence:			1.29		2.41		1.48

* Estimated values

** Emission rate considered too small to factor into the analysis

*** Estimated by multiplying the average percent distribution of the reported congener in tests 1A and 2A by the homologue in which the unreported congener is grouped.

TABLE 4

Maximum Individual Lifetime Risk At Receptor Where Residences Could Be Located, Including Expected Annual Cancer Incidence Within The Population Residing Within 50 km of the Philadelphia NW Incinerator

MAAGL[a] (pg/m^3)	Distance[b] (km)	Direction	Max Individual[c] Lifetime Risk	Annual[d] Cancer Incidence
1.40	0.85	NE	5.0×10^{-5}	0.07

(a) MAAGL = maximum annual ground level concentration of 2,3,7,8-TCDD equivalence at receptor where residences could be located.

(b) Distance MAAGL is from source.

(c) Maximum individual lifetime risk of cancer resulting from continuous 70-year exposure to (a), based upon the unit cancer risk estimate for inhalation exposure to 2,3,7,8-TCDD of 3.3×10^{-5} (pg/m^3)$^{-1}$ as derived by assuming 100% of 2,3,7,8-TCDD is adsorbed onto particulate; 75% of the inhaled particles are absorbed into the human system; a breathing rate of 20 m^3 of air/day for a 70 kg person. These assumptions factored with the carcinogenic potency slope of 1.56×10^5 (mg/kg-day)$^{-1}$ for 2,3,7,8-TCDD equals the unit risk estimate.

(d) Annual incidence is the aggregate of risks from PCDD/PCDF exposure to people living within the vicinity of the plant expressed as the number of cancer cases expected per year. There are 5 million people residing within 50 km of the incinerator.

TABLE 8. SUMMARY OF TOTAL TETRA-OCTA DIBENZO-p-DIOXIN AND DIBENZOFURAN EMISSIONS, MW UNIT NO. 1

Run No.	4A			5A			6A[a]			6B		
Date	3/02/85			3/03/85			3/05/85			3/05/85		
Start time	1130			0940			1340			1342		
End time	1710			1410			1850			1852		
Sample time, min	240			240			240			240		
Sample volume, Nm³ (dscf)	2.607 (92.065)			2.486 (87.803)			2.543 (89.798)			2.466 (87.074)		
Stack volumetric flow rate, Nm³/min (dscfm)	2,131 (75,262)			2,221 (78,450)			2,106 (74,389)			2,103 (74,262)		
Stack gas velocity, m/min (ft/sec)	1,551 (84.8)			1,509 (82.5)			1,527 (83.5)			1,529 (82.6)		
Stack gas temp., °C (°F)	268 (514)			267 (513)			265 (508)			268 (515)		
Stack gas moisture, % vol.	26.9			22.9			26.7			26.4		
Oxygen concentration, %	14.4			15.1			14.2			14.2		
Carbon dioxide concentration, %	5.7			5.1			5.7			5.7		
Percent isokinetic	106			97			104			103		
	ng	ng/Nm³	ng/sec	ng	ng/Nm³	ng/sec	ng	ng/Nm³	ng/sec	ng	ng/Nm³	ng/sec
2,3,7,8-TCDD	14	5.4	190	11	4.4	160	21	8.3	290	18	7.3	260
TCDD	510	190	6,900	370	150	5,500	400	160	5,500	1,300	530	19,000
P_5CDD	1,600	610	22,000	1,100	440	16,000	910	360	13,000	2,600	1,100	39,000
HxCDD	810	310	11,000	860	350	13,000	7,300	3,000	100,000	1,600	650	2,300
HpCDD	320	120	4,400	370	150	5,500	2,500	930	34,000	670	270	9,500
OCDD	160	61	2,200	130	52	1,900	950	370	13,000	260	100	1,500
Total Tetra-Octa CDD	3,400	1,300	46,000	2,800	1,100	42,000	12,000	4,700	170,000	6,400	2,600	91,000
2,3,7,8-TCDF	70	27	950	36	14	540	88	35	1,200	81	33	1,200
TCDF	1,400	540	19,000	900	360	13,000	1,400	550	19,000	2,600	1,100	39,000
P_5CDF	1,700	650	23,000	1,000	402	15,000	1,400	550	19,000	4,800	1,900	67,000
HxCDF	800	310	11,000	800	320	12,000	7,900	3,100	110,000	2,900	1,200	42,000
HpCDF	260	100	3,500	290	120	4,300	1,900	750	26,000	660	270	9,500
OCDF	26	10	350	25	10	370	110	43	1,500	57	23	800
Total Tetra-Octa CDF	4,200	1,600	57,000	3,000	1,200	45,000	13,000	5,000	180,000	11,000	4,500	160,000

[a] Low surrogate recovery on this sample.

TABLE 10. SUMMARY OF EMISSIONS OF 2,3,7,8-SUBSTITUTED DIBENZO-p-DIOXIN AND DIBENZOFURAN ISOMERS, MW UNIT NO. 1

Run No.	4A			5A			6A[a]			6B		
Date	3/02/85			3/03/85			3/05/85			3/05/85		
Start time	1130			0940			1340			1342		
End time	1710			1410			1850			1852		
Sample time, min	240			240			240			240		
Sample volume, Nm³ (dscf)	2.607 (92.065)			2.486 (87.803)			2.543 (89.798)			2.466 (87.074)		
Stack volumetric flow rate, Nm³/min (dscfm)	2,131 (75,262)			2,221 (78,450)			2,106 (74,389)			2,103 (74,262)		
Stack gas velocity, m/min (ft/sec)	1,551 (84.8)			1,509 (82.5)			1,527 (83.5)			1,529 (82.6)		
Stack gas temp., °C (°F)	268 (514)			267 (513)			265 (508)			268 (515)		
Stack gas moisture, % vol.	26.9			22.9			26.7			26.4		
Oxygen concentration, %	14.4			15.1			14.2			14.2		
Carbon dioxide concentration, %	5.7			5.1			5.7			5.7		
Percent isokinetic	106			97			104			103		
	ng	ng/Nm³	ng/sec	ng	ng/Nm³	ng/sec	ng	ng/Nm³	ng/sec	ng	ng/Nm³	ng/sec
2,3,7,8-TCDD	14	5.4	190	11	4.4	164	21	8.3	290	18	7.3	260
1,2,3,7,8-PCDD	130	50	1,800	85	34	1,270	61	24	842	b	b	b
1,2,3,4,7,8-HxCDD	100	38	1,400	98[c]	39	1,500	810	320	11,000	180	73	2,600
1,2,3,4,6,7,8-HpCDD	160	61	2,200	190[c]	76	2,800	1,200	470	17,000	310	130	4,600
OCDD	160	61	2,200	130[c]	52	1,900	950	370	13,000	260	100	3,500
2,3,7,8-TCDF	70	27	950	36	14	540	88	35	1,200	81	33	1,200
1,2,3,7,8/1,2,3,4,8-PCDF	160	61	2,200	100	40	1,500	140	55	1,900	b	b	b
2,3,4,7,8-PCDF	198	76	2,700	130[c]	52	1,900	630	250	8,700	b	b	b
1,2,3,4,7,8-HxCDF	130	50	1,800	97[c]	39	1,400	760	300	10,000	500	200	7,000
1,2,3,6,7,8-HxCDF	160	61	2,200	190[c]	76	2,800	2,100	830	29,000	320	130	4,600
1,2,3,4,6,7,8-HpCDF	190	73	2,600	220[c]	88	3,300	1,480	580	20,000	570	230	8,100
1,2,~~3,4~~,7,8,9-HpCDF	18	6.9	245	17[c]	6.8	250	97	38	1,300	26	11	380
OCDF	26	10	350	25	10	370	110	43	1,500	57	23	810

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[a] Low surrogate recovery on this sample; results should be considered an estimate.

[b] Unable to resolve PCDD/PCDF specific analytes.

[c] Only first replicate reported.

TABLE 11. SUMMARY OF EMISSIONS OF 2,3,7,8-SUBSTITUTED DIBENZO-p-DIOXIN AND DIBENZOFURAN ISOMERS, NW UNIT NO. 2

Run No.	1A			2A			3B		
Date	2/27/85			2/28/85			3/01/85		
Start time	1549			1200			0941		
End time	1956			1712			1427		
Sample time, min	192			240			240		
Sample volume, Nm³ (dscf)	2.059 (72.710)			2.785 (98.342)			2.573 (90.854)		
Stack volumetric flow rate, Nm³/min (dscfm)	2,378 (83,985)			2,488 (87,859)			2,360 (83,327)		
Stack gas velocity, m/min (ft/sec)	1,704 (93.2)			1,658 (90.7)			1,575 (86.1)		
Stack gas temp., °C (°F)	281 (538)			275 (528)			268 (514)		
Stack gas moisture, % vol.	24.8			21.3			22.1		
Oxygen concentration, %	15.9			15.5			15.4		
Carbon dioxide concentration, %	4.2			4.7			4.6		
Percent isokinetic	94.4			97.7			97.3		
	ng	ng/Nm³	ng/sec	ng	ng/Nm³	ng/sec	ng	ng/Nm³	ng/sec
2,3,7,8-TCDD	1.1 24	3.4 12	14 460	19	6.8	280	11	4.3	170
1,2,3,7,8-PCDD	55	27	1,100	150	54	2,200	69	27	1,100
1,2,3,4,7,8-HxCDD	130	63	2,500 14	91	33	1,400	100	39	1,500
1,2,3,4,6,7,8-HpCDD	170	83	3,300	190	68	2,800	220	86	3,400
OCDD	130	63	2,500	160	57	2,400	190	74	2,900
2,3,7,8-TCDF	18	8.7	350	51	18	760	36	14	550
1,2,3,7,8/1,2,3,4,8-PCDF	20	10	390 5.9	160	57	2,400 10	a	a	97 a
2,3,4,7,8-PCDF	27	13	520	160	57	2,400	140	54	2,100
1,2,3,4,7,8-HxCDF	130	63	2,500 14	110	39	1,600	78	30	1,200 10
1,2,3,6,7,8-HxCDF	130	63	250 1.4	110	39	1,600	170	66	2,600
1,2,3,4,6,7,8-HpCDF	230	110	4,400	150	54	2,200	150	58	2,300
1,2,3,4,7,8,9-HpCDF	18	8.7	350	17	6.1	250	17	6.6	260
OCDF	30	15	580	32	11	480	28	11	430

a Not discernible from other isomers present.

R-585-11-4-11

A FIELD TRIP REPORT FOR
NORTHWEST INCINERATOR DIOXIN SCREENING

PREPARED UNDER

TDD NO. F3-8410-02
EPA NO.
CONTRACT NO. 68-01-6699

FOR THE

HAZARDOUS SITE CONTROL DIVISION
U.S. ENVIRONMENTAL PROTECTION AGENCY

FEBRUARY 11, 1985

NUS CORPORATION
SUPERFUND DIVISION

SUBMITTED BY

ANDREW FREBOWITZ
ENVION. ENGINEER

REVIEWED BY

William Wentworth
WILLIAM WENTWORTH
ASST. MANAGER, REPORTS

APPROVED BY

GARTH GLENN
MANAGER, FIT III

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SECTION 1

1.0 INTRODUCTION

1.1 Authorization

NUS Corporation performed this work under Environmental Protection Agency Contract No. 68-01-6699. This specific report was prepared in accordance with Technical Directive Document No. F3-8410-02 for the Northwest Incinerator site located in Philadelphia, Pennsylvania.

1.2 Scope Of Work

NUS FIT III was tasked to conduct a dioxin screening at the Northwest Incinerator site, and to conduct an off-site sampling within a 2-kilometer radius of the site.

1.3 Summary

The Northwest Incinerator is an active incinerator used for the reduction of municipal solid waste from the city of Philadelphia. The site is owned and operated by the city of Philadelphia. The incinerator consists of 2 burner units designed to reduce waste volume by 85 percent. Furnace no. 1 was shutdown for rebricking on October 12, 1984; however, furnace no. 2 is inoperation. Each unit has emissions controlled by electrostatic precipitators (ESP). The incinerator fly ash is collected and mixed with the reduced waste, bottom ash. The ratio of ESP fly ash to bottom ash is 1:250.

The residue is collected and stockpiled on site. The pile under investigation consists of 200,000 cubic yards of residue, approximately 1 year's accumulation. Residue from the City of Philadelphia's East-Central Incinerator is also stored at the Northwest Incinerator pile. The city of Philadelphia contracts for the removal and disposal of the waste pile.

The analysis of samples of ESP fly ash taken in August 1984, revealed the presence of 2,3,7,8-TCDD (dioxin). The levels of dioxin in furnace no. 1 fly ash were as high as 28.2 parts per billion (ppb). The concentrations of dioxin in furnace no. 2 fly ash ranged from 3 to 5 ppb.

Site Name: Northwest Incinerator
TDD No.: F3-8410-02

FIT III conducted a sampling of the waste pile and bottom ash and ESP fly ash from the operating burner (furnace no. 2). In addition, off-site samples were collected within a 2-kilometer radius of the site, at locations determined by an EPA meteorological study. All samples were collected and processed in accordance with established protocol.

SECTION 2

Site Name: Northwest Incinerator
TDD No.: F3-8410-02

2.0 FIELD TRIP REPORT

2.1 Summary

From Tuesday, October 16 through Thursday, October 18, 1984, NUS FIT III staff members Andrew Frebowitz, Jeffery Case, Michael Nalipinski, Thomas Pearce, Charles Meyer, Mark Volatile, James Strickland, and Robert Howell visited the Northwest Incinerator site to conduct a dioxin screening. Weather for the duration of the sampling was clear and mild with morning low temperatures of 55°F and afternoon highs near 70°F.

The team collected 38 on-site samples; 32 samples were from the waste pile, including 3 samples from a 4.5 foot trench dug into the top of the pile by the Philadelphia Streets Department. Three samples each were collected of bottom ash and ESP fly ash. Off-site sample were collected from 38 locations within a 2-kilometer radius of the site. Split samples were processed and custody of the samples was given to the New Jersey Department of Environmental Protection (3 on-site samples) and to the city of Philadelphia (all samples).

2.2 Persons Contacted

2.2.1 Prior to Field Trip

Walter Lee
EPA Region III
Sixth and Walnut Streets
Philadelphia, PA 19106
(215) 597-6623

Al Cimorelli
EPA Region III - Meteorologist
Sixth and Walnut Streets
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Richaro Zipin
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Bruce Gledhill
Philadelphia Streets Department
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2.2.2 At the Site

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Charles Elmendorf
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8 East Hanover Street
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(609) 984-3068

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2.3 Synopsis of Daily Events

Date:	October 16, 1984
Weather:	Clear, 60-70°F
Personnel:	FIT III: Frebowitz, Case, Nalipinski, Volatile, Meyer, Strickland, Pearce, and Howell Other: Lee, Elmendorf, Lowry, Gledhill, and Zipin

Activities:

7:15 AM	FIT III arrived on site
7:15-7:50 AM	Command post set up
8:15 AM	First team downrange; sampling begins
8:40 AM	Hot line declared; blenders in
9:50 AM	Janet Luffy (EPA), Channels 3 and 6 arrived on site
1:00 PM	Sampling ends
1:30 PM	Blenders out; equipment breakdown, leave site

All waste pile samples, except Trenches A-C, were collected. ESP fly ash and bottom ash samples were also obtained.

Date:	October 17, 1984
Weather:	Clear and cool, 55°F; afternoon highs of 70°F
Personnel:	FIT III: Frebowitz, Case, Nalipinski, Volatile, Meyer, Strickland, Pearce, and Howell Other: Lee and Zipin

Activities:

7:40 AM	FIT III arrived on site
7:40-8:00 AM	Command post set up
8:10-1:25 PM	Off- and on-site samples collected
9:05 AM	Hot line declared; blenders in
1:45 PM	Blenders out; equipment breakdown
2:00 PM	Team off site

Site Name: Northwest Incinerator
TDD No.: F3-8410-02

Twenty-six off-site samples collected. Trench samples A, B, and C collected. ESP no. 2 and bottom ash no. 2 obtained.

Date:	October 18, 1984
Weather:	Cloudy, 55-60°F
Personnel:	FIT III: Frebowitz, Case, Nalipinski, Volatile, Meyer, Strickland, Pearce, and Howell Other: Lee and Zipin

Activities:

8:05 AM	FIT III arrived on site
8:05-8:30 AM	Command post set up
8:10-11:50 AM	Off- and on-site samples collected
11:05 AM	Hot line declared; blenders in
12:35 PM	Blenders out; equipment breakdown
12:45 PM	Team off site

Twelve off-site samples were collected. ESP no. 3 and bottom ash no. 3 samples were also collected.

TDD Number F3-8410-02
EPA Number

SAMPLE LOG

Site Name NORTHWEST INCINERATOR

CASE # 1327C BATCH 1

TRAFFIC REPORTS			SAMPLING LOCATION	PHASE	SAMPLE DESCRIPTION	DATE	TIME	pH	COMMENTS/OBSERVATIONS	LABORATORY
Organic	Inorganic	High Hazard								
			STANDARD	SOL	1327C-21	10/18	1200		STANDARD	U.S. TESTING
			BACKGROUND	↓	1327C-22	10/18	1125		BLANK	↓
			BACKGROUND TO SPIKE		1327C-23	10/18	1125		TO BE SPIKED BY LAB	
			21		1327C-24	10/17	1035		DUPLICATE	

TDD Number F3-8410-02
EPA Number

SAMPLE LOG

Site Name NORTHWEST INCINERATOR

CASE # 3435 BATCH 1

TRAFFIC REPORTS			SAMPLING LOCATION	PHASE	SAMPLE DESCRIPTION		DATE	TIME	pH	COMMENTS/OBSERVATIONS	LABORATORY
Organic	Inorganic	High Hazard									
			TP1A	SOL.	DC009601	TOP OF PILE	10/16	0915		SURFACE	ETC
			TP1B		DC009602	TOP OF PILE	10/16	0915		0.5 ft	
			TP2A		DC009603	TOP OF PILE	10/16	0900		SURFACE	
			TP2B		DC009604	TOP OF PILE	10/16	0900		10 inches below surface	
			TP3B		DC009605	TOP OF PILE	10/16	0910		1 ft.	
			TP4A		DC009606	TOP OF PILE	10/16	0840		SURFACE	
			TP4B		DC009607	TOP OF PILE	10/16	0840		1 foot deep	
			TP5A		DC009608	TOP OF PILE	10/16	0835		SURFACE	
			TP5B		DC009609	TOP OF PILE	10/16	0835		1 foot deep	
			TP6A		DC009610	TOP OF PILE	10/16	0825		SURFACE	
			TRENCH A		DC009611	TRENCH	10/17	1230		3 ft.	
			TRENCH B		DC009612	TRENCH	10/17	1230		4 ft.	
			S-4 A		DC009613	SIDE OF PILE	10/16	1105		SURFACE	
			S-4 B		DC009614	SIDE OF PILE	10/16	1105		1 ft. into bank	
			S-5 A		DC009615	SIDE OF PILE	10/16	1110		SURFACE	
			S5B		DC009616	SIDE OF PILE	10/16	1110		1 ft into bank	
			S6A		DC009617	SIDE OF PILE	10/16	1115		SURFACE	
			S6B		DC009618	SIDE OF PILE	10/16	1115		1.5 ft. into bank	
			21		DC009619	OFF-SITE	10/17	1035		Soil-[illegible]	
			BOTTOM ASH	✓	DC009620	FURNACE NO. 3 BOTTOM ASH	10/16	1300		DUPLICATE	✓

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TDD Number F3-8410-01
EPA Number

SAMPLE LOG

Site Name Northwest Incinerator

CASE # 3435 Batch 1

TRAFFIC REPORTS			SAMPLING LOCATION	PHASE	SAMPLE DESCRIPTION	DATE	TIME	pH	COMMENTS/OBSERVATIONS	LABORATORY
Organic	Inorganic	High Hazard								
			RINSATE #2	AQ.	DC009621 RINSATE	10/16	1145			ETC
			STANDARD	SOL	DC009622	10/18	1200		STANDARD	↓
			BLANK	↓	DC009623 BLANK	10/15	1125			
			BLANK TO SPIKE		DC009624	10/18	1125		TO BE SPIKED BY LAB	

TDD Number F3-8410-02
EPA Number

SAMPLE LOG

Site Name NORTHWEST INCINERATOR

CASE 3435 BATCH 2

TRAFFIC REPORTS			SAMPLING LOCATION	PHASE	SAMPLE DESCRIPTION	DATE	TIME	pH	COMMENTS/OBSERVATIONS	LABORATORY
Organic	Inorganic	High Hazard								
			S 7A	SOL	DC009701 SIDE OF PILE	10/16	1140		Surface	ETC
			S 7B		DC009702 SIDE OF PILE	10/16	1140		1 ft. into pile	
			S 8A		DC009703 SIDE OF PILE	10/16	1200		Surface	
			S 8B		DC009704 SIDE OF PILE	10/10	1200		1 foot into pile	
			8		DC009705 OFF-SITE	10/17	0900		off-site surface	
			9		DC009706 OFF-SITE	10/17	0855		off site surface	
			10		DC009707 OFF-SITE	10/17	0845		off site surface	
			11		DC009708 OFF-SITE	10/17	0830		off site surface	
			12		DC009709 OFF-SITE	10/17	0825		off site surface	
			18		DC009710 OFF-SITE	10/17	0930		off site surface	
			17		DC009711 OFF-SITE	10/17	0935		off site surface	
			15		DC009712 OFF-SITE	10/17	0945		off site surface	
			14		DC009713 OFF-SITE	10/17	0955		off site surface	
			16		DC009714 OFF-SITE	10/17	0940		off site surface	
			20		DC009715 OFF-SITE	10/17	1045		off site surface	
			19		DC009716 OFF-SITE	10/17	1055		off site surface	
			34		DC009717 OFF-SITE	10/17	1120		off site surface	
			1		DC009718 OFF-SITE	10/17	1125		off site surface	
			27		DC009719 OFF-SITE	10/17	1130		off site surface	
			Rinsate # 3	Aq	DC009720 Rinsate	10/17	0930			

TDD Number F3-8410-02
EPA Number

SAMPLE LOG

Site Name NORTHWEST INCINERATOR

CASE 3435 BATCH 2

TRAFFIC REPORTS			SAMPLING LOCATION	PHASE	SAMPLE DESCRIPTION	DATE	TIME	pH	COMMENTS/OBSERVATIONS	LABORATORY
Organic	Inorganic	High Hazard								
			ESP	SOL	DC005721 ESP NO 2 FLYASH	10/18	1230		DUPLICATE	ETC
			STANDARD	↓	DC005722	10/18	1300			↓
			BLANK		DC005723 BLANK	10/18	1125			
			BLANK TO SPIKE		DC005724	10/18	1125		TO BE SPIKED BY LAB	

TDD Number F3-8410-02
EPA Number

SAMPLE LOG

Site Name NORTHWEST INCINERATOR

CASE No. 3435 BATCH 3

TRAFFIC REPORTS			SAMPLING LOCATION	PHASE	SAMPLE DESCRIPTION	DATE	TIME	pH	COMMENTS/OBSERVATIONS	LABORATORY
Organic	Inorganic	High Hazard								
			28	SOL	DC009801 OFF-SITE	10/17	1135		off-site surface	CAL ANALYTICAL
			2	↓	DC009802 ↓	10/17	1145		↓	↓
			3	↓	DC009803 ↓	10/17	1300		↓	↓
			26	↓	DC009804 ↓	10/17	1230		↓	↓
			25	↓	DC009805 ↓	10/17	1235		↓	↓
			24	↓	DC009806 ↓	10/17	1240		↓	↓
			ESP #2	↓	DC009807 ESP NO. 2 FLYASH	10/17	1315			↓
			BOTTOM ASH #2	↓	DC009808 FURNACE NO. 2 BOTTOM ASH	10/17	1320			↓
			29	↓	DC009809 OFF-SITE	10/18	0900		off-site surface	↓
			30	↓	DC009810 ↓	10/18	0910		↓	↓
			31	↓	DC009811 ↓	10/18	1055		↓	↓
			32	↓	DC009812 ↓	10/18	1025		↓	↓
			33	↓	DC009813 ↓	10/18	1040		↓	↓
			23	↓	DC009814 ↓	10/18	1010		↓	↓
			35	↓	DC009815 ↓	10/18	0930		↓	↓
			36	↓	DC009816 ↓	10/18	0940		↓	↓
			37	↓	DC009817 ↓	10/18	0950		↓	↓
			38	↓	DC009818 ↓	10/18	0955		↓	↓
			21	↓	DC009819 ↓	10/17	1110		↓	↓
			RINSATE #4	AQ	DC009820 RINSATE	10/17	[illegible]20			↓

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TDD Number F3-8410-02
EPA Number

SAMPLE LOG

Site Name NORTHWEST INCINERATOR

CASE NO. 3135 BATCH 3

TRAFFIC REPORTS			SAMPLING LOCATION	PHASE	SAMPLE DESCRIPTION	DATE	TIME	pH	COMMENTS/OBSERVATIONS	LABORATORY
Organic	Inorganic	High Hazard								
			STANDARD	SOL.	DX009821 STANDARD	10/18	1400			CAL ANALYTICAL
			5	↓	DX009822	10/18	0855		DUPLICATE	↓
			BLANK	↓	DX009823 BLANK	10/18	1125			↓
			BLANK & SPIKE	↓	DX009824	10/18	1135		TO BE SPIKED AT LAB	↓

2.5 Site Observation

- The site is active. Furnace no. 2 is operating, while furnace no. 1 is shutdown for repairs.
- Residue is stockpiled on site.
- Residue from the East-Central Incinerator is also stored on site.
- The waste pile was approximately 200 feet by 400 feet. Its maximum elevation was 80 feet.
- The slope of the waste pile was approximately 30 to 40 percent.
- Waste material in the pile consists of burnt metal and glass and compacted ash. Paper, which was not destroyed by the incineration process, was also seen in the waste pile.
- The pile is compacted by a bulldozer.
- No HNU or mini-alert readings were recorded above background.
- There is a diversion ditch on the western side of the waste pile.
- The northern end of the pile extends to a rock wall.
- A water-treatment pond is immediately east of the pile.
- The site is fenced on all but the northern end. The rock wall prevents access from the north.
- Off-site samples were collected from the city property (within 10 feet of the curb) in residential areas. Consent by property owners was given before collection of any samples from private property.

TDD Number F3-8410-02
EPA Number

SAMPLE LOG

Site Name NORTHWEST INCINERATOR

CASE # 1327C BATCH 1

TRAFFIC REPORTS			SAMPLING LOCATION	PHASE	SAMPLE DESCRIPTION		DATE	TIME	pH	COMMENTS/OBSERVATIONS	LABORATORY
Organic	Inorganic	High Hazard									
			BOTTOM ASH	SOL	1327C-1	FURNACE No 1 RESIDUE	10/16	1300			U.S Testing
			BOTTOM ASH #3		1327C-2	FURNACE No 1 RESIDUE	10/18	1145			
			ESP ASH		1327C-3	NO. 1 ESP FLYASH	10/16	1250			
			ESP ASH #3		1327C-4	NO. 2 ESP FLYASH	10/18	1145			
			S1-A		1327C-5	SIDE OF WASTE PILE	10/16	0955		4 ft. from bottom	
			S1-B		1327C-6	SIDE OF PILE	10/13	0955		1 ft. from bottom	
			S2-A		1327C-7	SIDE OF PILE	10/16	1000		3 ft. from bottom	
			S2-B		1327C-8	SIDE OF PILE	10/16	1000		BASE OF PILE	
			S3-A		1327C-9	SIDE OF PILE	10/16	1005		SURFACE	
			S-3B		1327C-10	SIDE OF PILE	10/16	1005		1 ft. into pile	
			4		1327C-11	OFF-SITE	10/17	1150		OFF-SITE	
			7		1327C-12	OFF-SITE	10/17	0905		OFF-SITE	
			13		1327C-13	OFF-SITE	10/17	1000		OFF-SITE	
			TP6B		1327C-14	TOP OF PILE	10/16	0825		2 ft. in depth	
			TRENCH C		1327C-15	TRENCH DUG IN TOP OF PILE	10/17	1225		4.5 ft. in depth	
			TP3-A		1327C-16	TOP OF PILE	10/18	0910		surface of pile	
			E-C		1327C-17	INCINERATOR RESIDUE	10/18	1020		Residue from East-Central Incinerator	
			5		1327C-18	OFF-SITE	10/18	0855		soil - channel 57	
			6	✓	1327C-19	OFF-SITE	10/18	0850		air filter - channel 57	
			RINSATE #1	AQ	1327C-20	RINSATE	10/16	0930			✓

Photo 1 - Charles Meyer collecting TP6A sample.

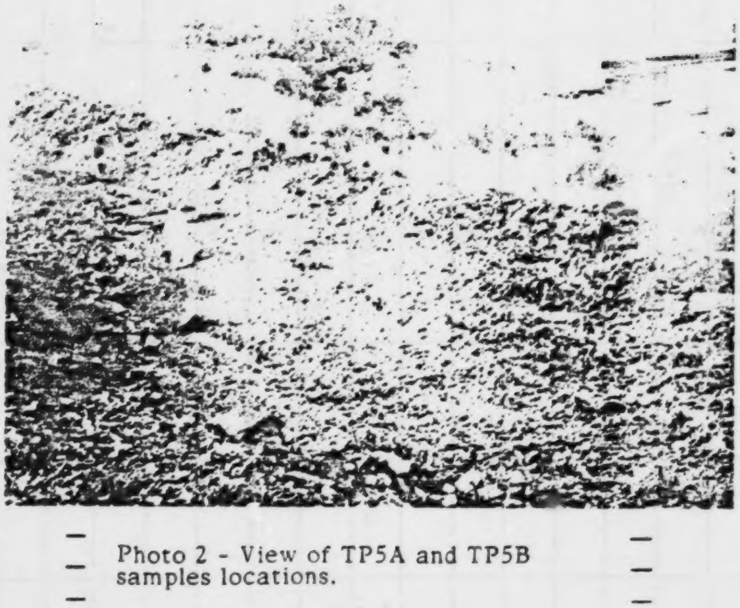


Photo 2 - View of TP5A and TP5B samples locations.

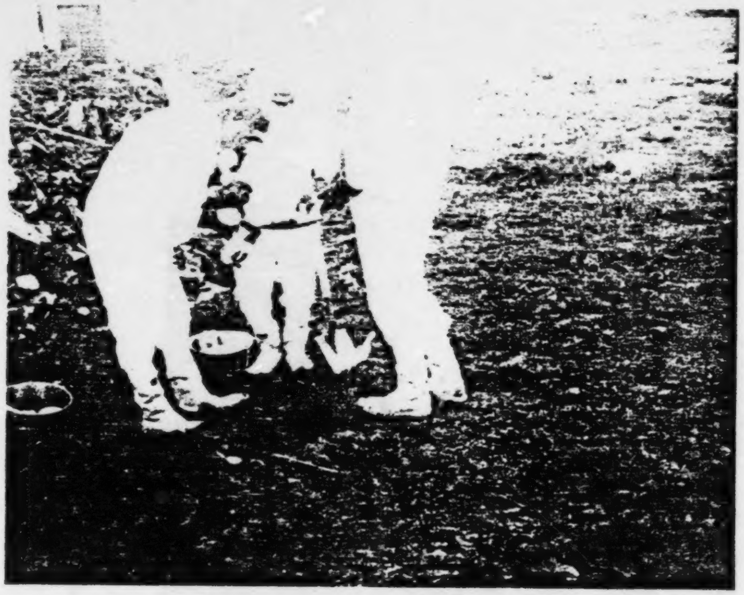


Photo 3 - Sampling at locations TP4A and TP4B.

Photo 4 - James Strickland collecting sample TP2A.

Photo 5 - Thomas Pearce and Chuck [illegible]eyer at sample locations TP3A and TP3B

Photo 6 - James Strickland collecting TP1B sample.

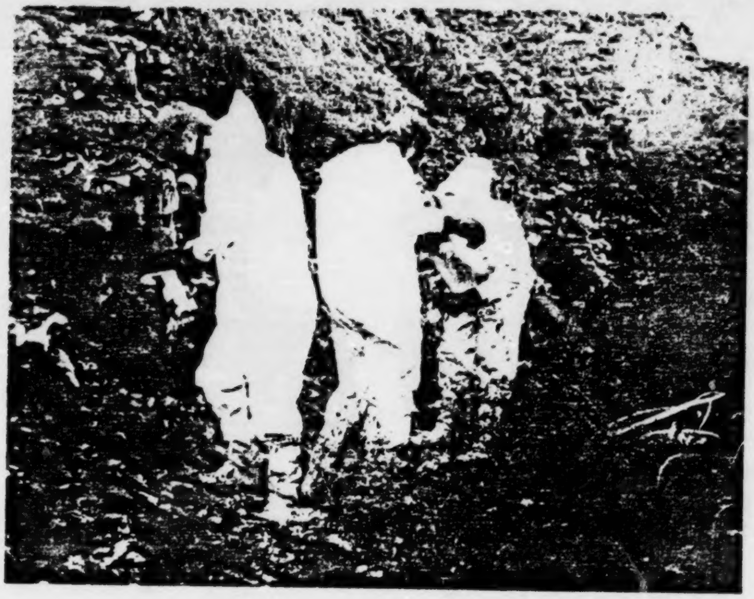


Photo 7 - Collection of samples S2A and S2B.

Photo 8 - Sample locations S3A and S3B.

Photo 9 - Sampling of East-Central Incinerator residue.

Photo 10 - Thomas Pearce collecting sample S4A.

Photo 11 - Collecting samples S5A and S5B.

Photo 12 - Sampling at locations S7A and S7B.

Photo 13 - Thomas Pearce collecting sample no. 7.

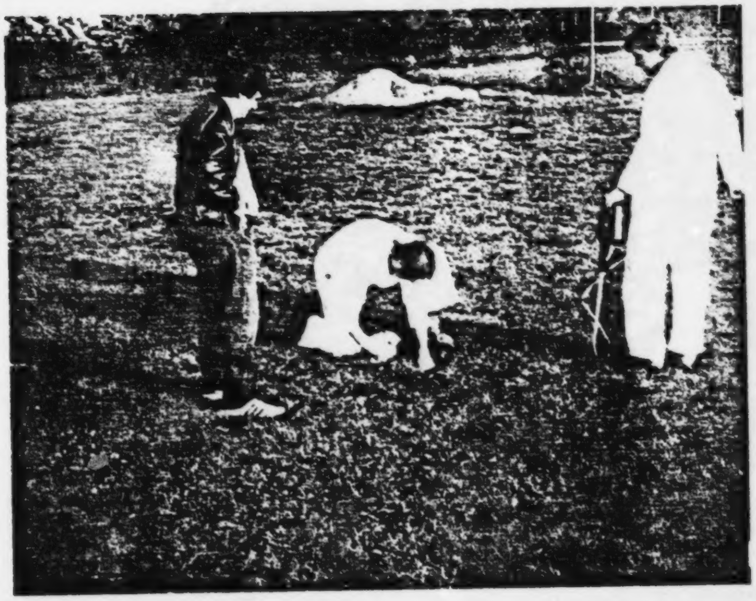


Photo 14 - Jeffrey Case collecting sample no. 1 at Saul High School.

Photo 15 - Surveying and collecting off-site location no. 17.

Photo 16 - Station no. 16, sampling 712 Shawmont Avenue.

Photo 17 - Off-site sampling location no. 13.

Photo 18 - Thomas Pearce collecting sample no. 21 at Schuylkill Valley Nature Center.

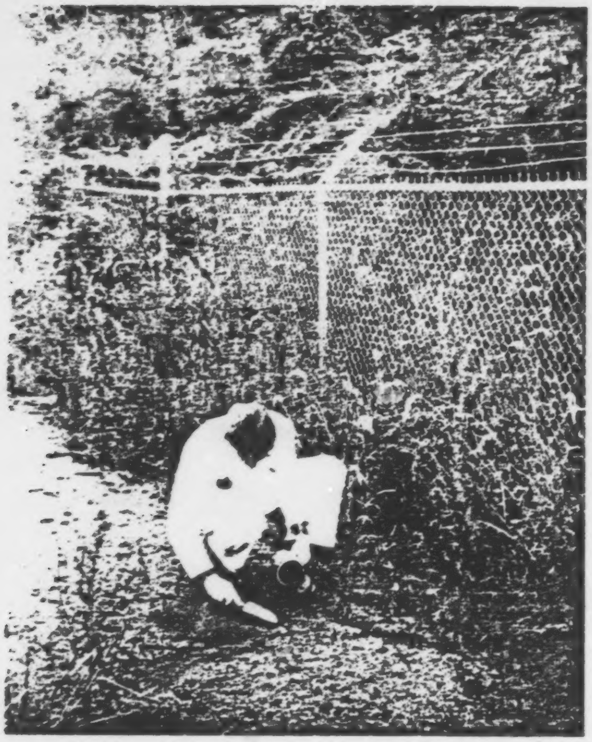


Photo 19 - Thomas Pearce collecting off-site location no. 1 sample.

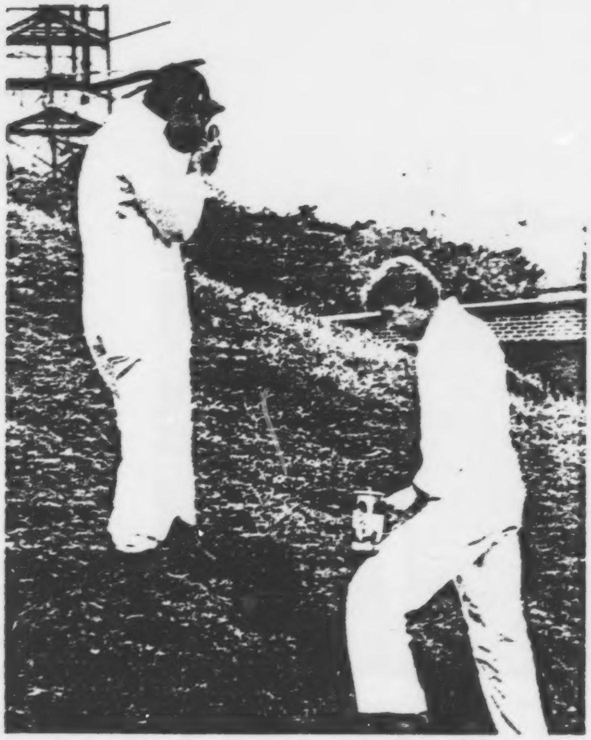


Photo 20 - Michael Nalipinski and Thomas Pearce at off-site location no. 2.

Photo 21 - View of trench digging and sampling. Taken from command post.

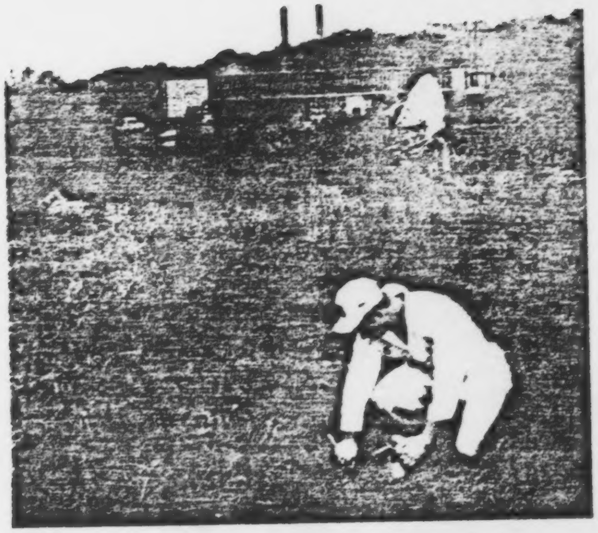


Photo 22 - James Strickland collecting off-site sample no. 5 at Channel 57. Incinerator is in background.

Photo 23 - View of command post and blending/decontamination area.

Photo 24 - View of sample processing.

APPENDIX A

1. COST CENTER:

ACCOUNT NO.:

REM/FIT ZONE CONTRACT
TECHNICAL DIRECTIVE DOCUMENT (TDD)

2. NO.: F3-8410-02

3. PRIORITY:
☒ HIGH
☐ MEDIUM
☐ LOW

4. ESTIMATE OF TECHNICAL HOURS: 450*

4A. ESTIMATE OF SUBCONTRACT COST:

5. EPA SITE ID:

5A. EPA SITE NAME: Northwest Incinerator Roxborough, PA

6. COMPLETION DATE: 4 wks after field work

7. REFERENCE INFO.:
☐ YES ☐ NO
☐ ATTACHED
☐ PICK UP
Contact Walter Lee

8. GENERAL TASK DESCRIPTION: Perform dioxin sampling at the subject site (enforcement support)

9. SPECIFIC ELEMENTS:
1.) Obtain all available background information from EPA.
2.) Perform field recon of site to determine sample locations.
3.) All sampling to be performed according to the most recent dioxin protocol as written by EPA Region VII.
4.) EPA (Walter Lee) will coordinate lab analysis.
5.) Triple splits will be provided for all on site samples. Double splits will be provided for all off site samples.
6.) Maintain chain of custody for all samples.
7.) Document all sampling and related activities.
8.) Drum for proper disposal all contaminated clothing and materials, drums will remain on site, EPA will arrange.
9.) EPA will arrange for spiked samples.
10.) Prepare and submit field trip report including photo documentation.

10. INTERIM DEADLINES:

11. DESIRED REPORT FORM: FORMAL REPORT ☒ LETTER REPORT ☐ FORMAL BRIEFING ☐

OTHER (SPECIFY):

12. COMMENTS: Coordinate activities with Walter Lee.
*Authorized overtime for field sampling if needed.

13. AUTHORIZING RPO: Harold G Byer
(SIGNATURE)

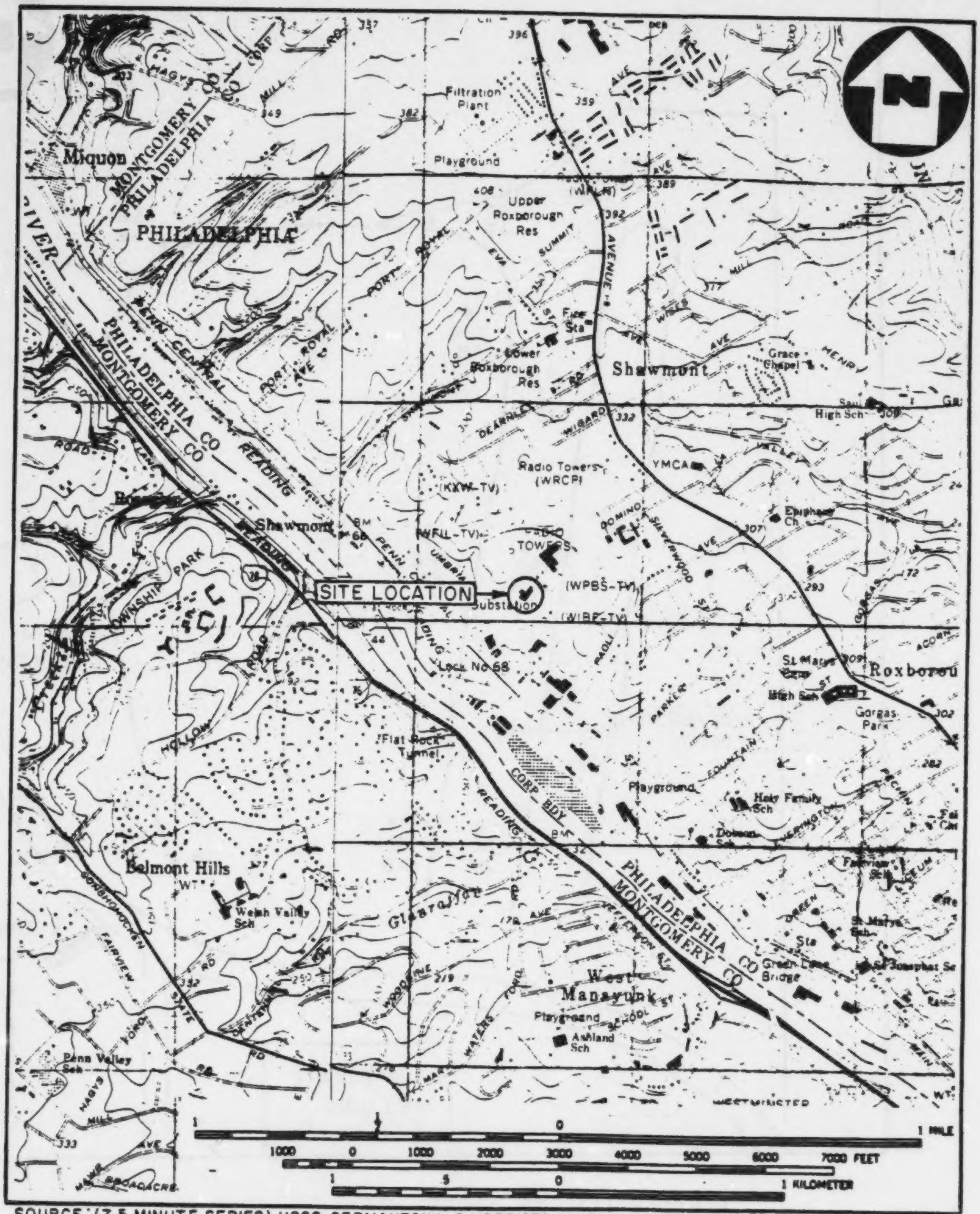
14. DATE: 10/30/84

15. RECEIVED BY: ☑ ACCEPTED ☐ ACCEPTED WITH EXCEPTIONS ☐ REJECTED
(CONTRACTOR RPM SIGNATURE)

16. DATE: 1/5/84

Sheet 1	White – FITL Copy	Sheet 3	Pink – Contracting Officer's Copy (Washington, D. C.)
Sheet 2	Canary – DPO Copy	Sheet 4	Goldenrod – Project Officer's Copy (Washington, D. C.)

APPENDIX B



SOURCE: (7.5 MINUTE SERIES) USGS GERMANTOWN & NORRISTOWN, PA. QUADS.

SITE LOCATION MAP

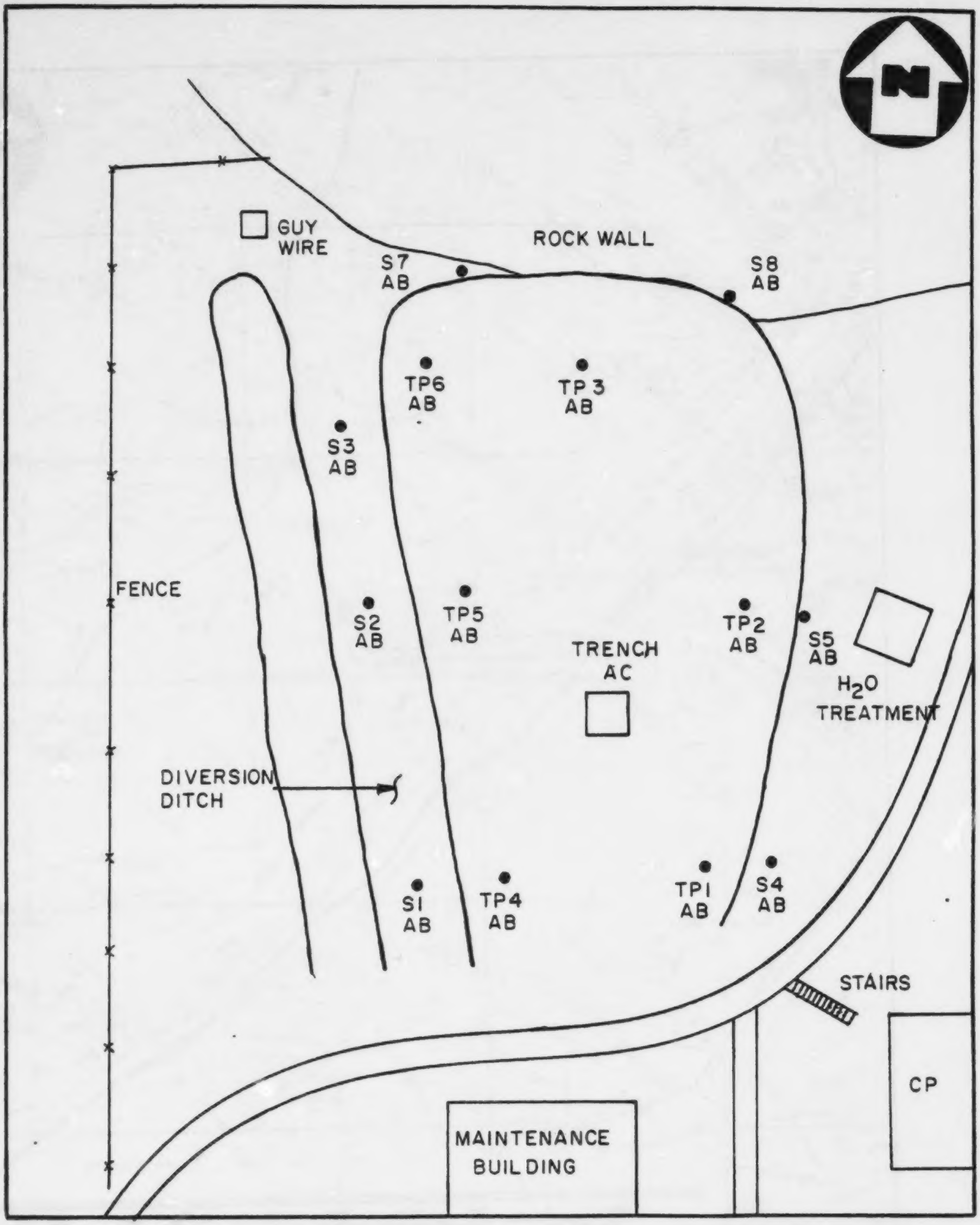
NORTH WEST PHILA. INCINERATOR, PHILA., PA.

SCALE 1:24000

FIGURE 1

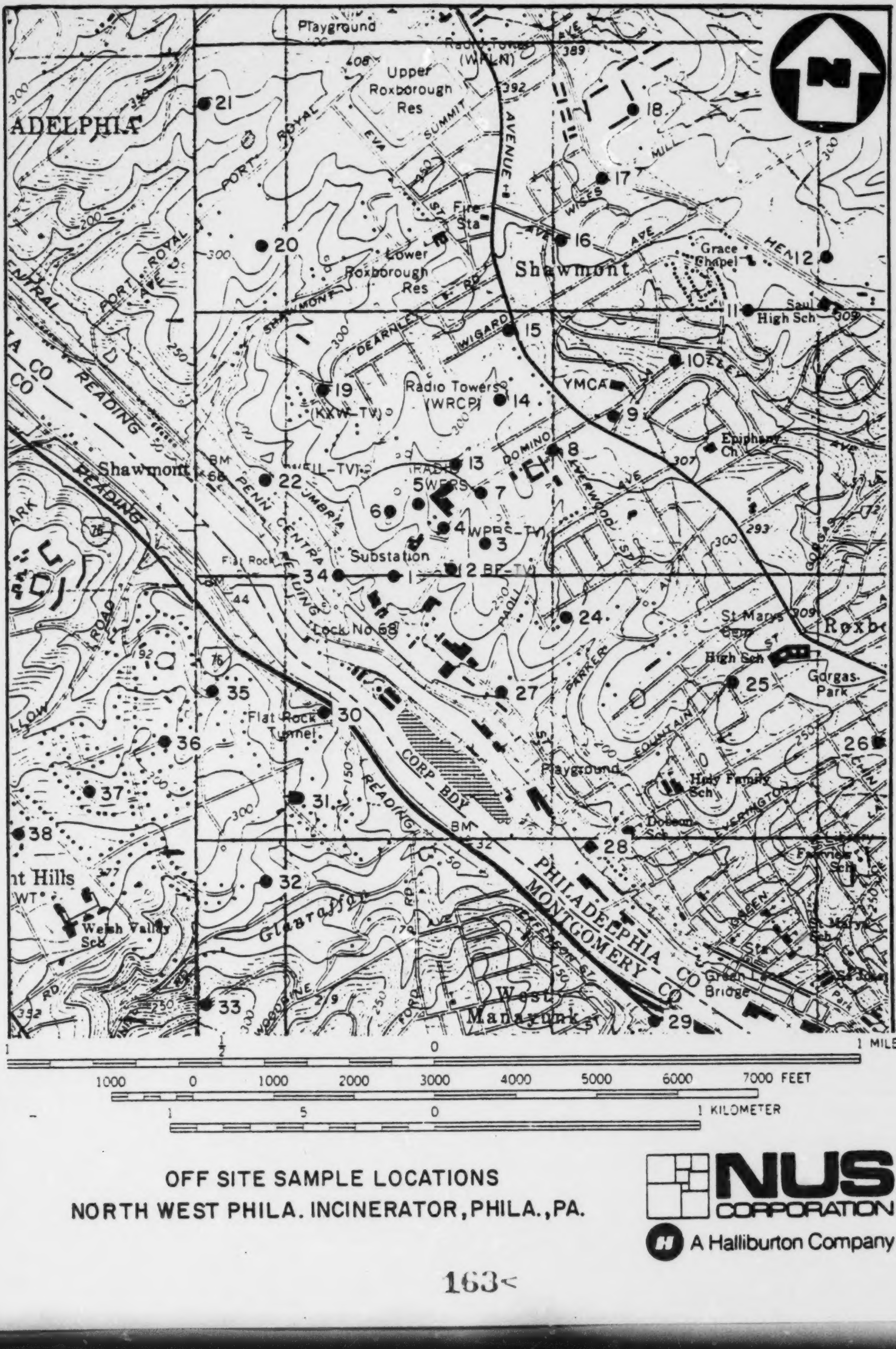
NUS CORPORATION

A Halliburton Company



ON SITE SAMPLE LOCATION
NORTH WEST PHILA. INCINERATOR, PHILA., PA.
(NO SCALE)

NUS CORPORATION
A Halliburton Company



OFF SITE SAMPLE LOCATIONS
NORTH WEST PHILA. INCINERATOR, PHILA., PA.

NUS CORPORATION
A Halliburton Company

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Region III - 6th & Walnut Sts.
Philadelphia, Pa. 19106

SUBJECT: EPA Laboratory Analysis
Dixoin Concentration - Ash Storage
Philadlephia NW Incinerator

DATE: DEC 27 1984

FROM: Robert Kramer, Coordinator
NSWS (3ES00)

Bob Kramer

TO: Bruce Smith, Chief
Hazardous Waste Enforcement Branch (3ES10)

Ray Cunningham, Director
Air Management Division (3AM00)

Attached are the analytical results of dioxin concentration. The analytical results have been quality assured and can be used to answer all questions regarding dioxin concentration.

Please note that eight sample results are being provided instead of the nine that were planned. Sample location S7B (Sample #DC009702) wasn't sent to the EPA labs for analysis.

DIOXIN ANALYSIS - ASH STORAGE PILES, PHILADLEPHIA NORTHWEST MUNICIPAL INCINERATOR

EPA Lab (Troika) Number	EPA Field Number	Location	Results (2,3,7,8 TCDD-PPT)
E 027	1327-06	S2A	41
E 028	1327-14	TP-6B	81
E 029	1327-27	Trench B	36
E 030	1327-28	Trench C	49
E 031	Method Blank		Non-Detectable
E 032	Lab Control Spike		4450
E 033	DC009610	TP-6A	89
E 034	DC011502	TP-1A	73
E 035	DC011503	TP-1B	26
E 036	DC011501	S5A	68
E 037	Matrix Blank		N.D.
E 038	Matrix Blank		N.D.

Milner

DEC 17 1984

Ms. Georgi Jones
Chamblee 28 S
Room 9, S.I.G.
Center for Disease Control
Atlanta, GA 30333

Dear Ms. Jones:

As a followup to our telephone conversation on December 13, 1984, the information you requested regarding Philadelphia's incinerator ash disposal site and material characteristics are presented below:

Waste Characteristics - The majority of combined bottom ash and flyash samples from the Philadelphia Northwest and East-Central Municipal Incinerators are expected to yield non-detectable levels of dioxin. There is a possibility that some samples may be in the range of very low concentrations not to exceed 3-5 ppb of 2,3,7,8 TCDD.

Expected Information on Disposal Site -

Facility Name: Sanitary Landfill Company, Inc.
Monessen, PA 15062

Facility Location: Westmoreland County, PA

PA Dept. of Environmental Resources Landfill Permit #100277

Landfill Engineering Characteristics: Natural clay liner with a permeability of 10^{-6} cm/sec. gravity flow leachate collection system with interception, treatment and discharge.

Please note that other landfills with similar engineering characteristiacs are being considered as possible disposal sites.

In addition, I have enclosed information collected during other municipal incinerator studies dealing with measurements of dioxin.

Even though we do not have the final dioxin ash sample results for the Northwest and East-Central Incinerators, we fully expect those samples to be within the range stated above.

As we discussed during our telephone conversation of December 13, 1984, I ask that you consider this information during your health assessment subject to verification when additional ash samples (9) become available during the week of December 23, 1984. If at all possible, we would appreciate your response by December 19, 1984.

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If you have further questions concerning either the information presented in this correspondence or the sample results when they become available, please do not hesitate to call W. Ray Cunningham (215/597-9390) or me at (215/597-9812).

EPA appreciates your cooperation in this matter.

Sincerely,

Stanley L. Laskowski
Deputy Regional Administrator

Enclosure

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best available copy.

Enclosure

Facility	Typical Stack Concentration ng/dscm		2,3,7,8, TCDD Flyash Concentration, ppb	Total TCDD Flyash Concentration, ppb
	Total TCDD	2,3,7,8, TCDD		
Combined results of 5 municipal incinerators	N.D.- 8.5	N.D. - 3.5	Not Determined	Not Determined
VA incinerator	240	50	1.4 - 2.9	170
Incinerator C	-	-	2.0	7.3

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service
Agency for Toxic Substances
and Disease Registry

Memorandum

ate December 26, 1984

om Assistant Administrator
Agency for Toxic Substances and Disease Registry

bject Review of Northwest Incinerator Dioxin Screening Results of Ash Pile
Philadelphia, Pennsylvania

Charles J. Walters
Public Health Advisor
EPA Region III

As requested, the Center for Environmental Health, Centers for Disease Control has reviewed the subject data provided on December 26, 1984, on the Northwest Incinerator to determine if the concentrations detected would prohibit movement and storage of the ash in the landfill as described in the communication from Stanley L. Laskowski, Deputy Regional Administrator EPA dated December 14, 1984.

It is our understanding that the level of detection used in the analysis of the specimens was 20 parts per trillion (ppt) of 2,3,7,8 TCDD and that usual and customary sampling and analytical procedures were used. We further understand that full quality control and quality assurance checks have been successfully passed.

Given the values ranging from non-detect to 89 ppt of 2,3,7,8 TCDD we do not feel that a significant public health threat will be posed by the dioxin utilizing the proposed disposal plan. This assumes that the usual compaction and cover practices at the sanitary landfill are maintained.

Vernon N. Houk, M.D.

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service
Agency for Toxic Substances
and Disease Registry

Memorandum

Date December 26, 1984

From Assistant Administrator
Agency for Toxic Substances and Disease Registry

Subject Review of Northwest Incinerator Dioxin Screening Results of Ash Pile
Philadelphia, Pennsylvania

To Charles J. Walters
Public Health Advisor
EPA Region III

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Vernon N. Houk, M.D.

13:40:25- 87938 - 3 - 1 Y D WK2 517

ANALYSIS REPORT

Lancaster Laboratories

LLI Sample No. TL 347055

City of Philadelphia
Room 1540 MSB
Philadelphia, PA 19102

Date Reported 12/14/84
Date Submitted 12/10/84
Discard Date 1/14/85
P. O. No.
Collected by Client

EP Toxicity Leachate of Solid Waste
Collected on 12/10/84 (0830) by BG

ANALYSIS	AS RECEIVED		LAB CODE
pH	5.07		200-103-00
Ammonia Nitrogen	1.7	mg/l	221-143-02
Oil & Grease	< 2.	mg/l	231-126-03
Phenolics	< 0.007	mg/l	233-099-05
Antimony	0.004	mg/l	244-054-01
Arsenic	< 0.004	mg/l	245-054-03
Barium	0.5	mg/l	246-054-01
Cadmium	0.271	mg/l	249-054-01
Chromium	< 0.05	mg/l	251-054-01
Copper	0.78	mg/l	253-054-01
Lead	1.79	mg/l	255-054-01
Mercury	< 0.001	mg/l	259-054-03
Molybdenum	< 0.1	mg/l	260-054-01
Nickel	0.56	mg/l	261-054-01
Selenium	< 0.1	mg/l	264-054-03
Silver	< 0.01	mg/l	266-054-01
Zinc	41.7	mg/l	272-054-01
Hexavalent Chromium	< 0.02	mg/l	276-041-01
Total Org. Halogen	< 20.	ppb	574-021-08

The above analyses were performed on an EP Toxicity leachate of the submitted waste prepared according to the procedure specified in Federal Register May 19 1980 p. 33127.

Leachate Preparation:
150.0 grams waste / 2400 ml distilled water
Initial pH = 8.07 324 ml of 0.5 N Acetic Acid was used to maintain the pH at 5.0 Final volume was 3000 ml.

The characteristic of EP Toxicity is determined by whether any of the contaminant concentrations (mg/l) in the leachate exceed the following maxima (100 X's Primary Drinking Water Standards): Arsenic 5.0; Barium 100.0; Cadmium 1.0; Chromium 5.0; Lead 5.0 ; Mercury 0.2; Selenium 1.0; Silver 5.0; Endrin 0.02; Lindane 0.4; Methoxychlor 10.0 Toxaphene 0.5; 2,4-D 10.0; 2,4,5-TP 1.0

The above analyses indicate that the submitted sample DOES NOT exhibit the characteristic of EP Toxicity as defined in Section 261.24 Federal Register 1980 p. 33122.

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

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Continued on Page 2

ANALYSIS REPORT

Lancaster Laboratories

City of Philadelphia
Room 1540 MSB
Philadelphia, PA 19102

LLI Sample No. TL 34903
*** Page 2 ***
Date Reported 12/14/84
Date Submitted 12/10/84
Discard Date 1/14/85
P. O. No.
Collected by Client

EP Toxicity Leachate of Solid Waste
Collected on 12/10/84 (0830) by BG

ANALYSIS	AS RECEIVED	LAB CODE

1 COPY TO City of Philadelphia Attn: Mr. Tyler Wren Dep City S

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

2191 18750 66900

Respectfully submitted
Lancaster Laboratories, Inc.

Reviewed and Approved by:
J. Wilson Hershey M.S. Mgr.
Environmental

NORTHWEST INCINERATOR
OPERATING PROCEDURES AND
CONDITIONS STUDY

TASK FORCE REPORT
JANUARY, 1986

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INTRODUCTION

The Northwest Incinerator was constructed in 1960. During the twenty-four years that this facility has been utilized for trash disposal by the City of Philadelphia, air pollution control efforts have been primarily directed toward reducing and maintaining the emission of particulates and odorous gases to compliance levels. Several flyash collection and combustion control improvements have been implemented to achieve this goal.

Numerous stack tests have been conducted during the past ten years to determine particulate emission concentrations. Several of the reported results exceed the compliance standard (.10 gr/DSCF at 12% CO_2). However, values obtained during the most recent particulate emissions testing, conducted in 1981, are well within the above standard.

Inspections, visible emissions observations and investigations of odor and flyash complaints have been routinely conducted by Air Management Services and intermittently by the Pennsylvania Department of Environmental Resources and/or the Environmental Protection Agency, to evaluate the effectiveness of air pollution control measures. These activities identified the need for the previously noted improvements and have indicated areas of continuing concern - temperature fluctuations, equipment breakdowns, residue removal problems, defective control panel gauges and the lack of continuous emission monitoring equipment.

On August 1 and 2, 1984, an EPA contractor conducted testing at the Northwest incinerator. The testing included analysis of flyash samples to determine dioxin levels. The dioxin content of two samples taken from the unit #2 collector was higher than anticipated.

As a result of questions raised by the above testing and prior environmental concerns, an assessment of Philadelphia's trash incineration facilities was undertaken in November, 1984. The above assessment included an examination of operating practices related to air contaminant emissions.

This report contains the findings and recommendations resulting from the operating practices examination.

PURPOSE AND SCOPE

PURPOSE

To evaluate operating procedures and process parameters related to:

1. Oxidation/thermal destruction of combustible air contaminants
2. Control of particulate emissions and odors

SCOPE

The study included the following activities:

Agency Records Review

Prior inspection findings, descriptions of equipment/operating modifications and stack test reports contained in Air Management Services' and Department of Environmental Resources' files were reviewed to extract background operating practices/control information.

Plant Records Review

Plant records (temperature charts, draft charts, precipitator data and maintenance log) covering operations during the third quarter of 1984 were analyzed to obtain a profile of incinerator operating conditions and maintenance procedures.

On-Site Observations

Extensive on-site observations of operating procedures and process conditions were conducted on December 3, 1984 (night shift), December 4, 1984 (evening shift) and December 5, 1984 (daylight shift). Data available from on-site instruments was supplemented with volumetric flow measurements.

Literature Review

Reports of dioxin studies available in recent literature publications were reviewed to obtain emission/control information pertinent to municipal incinerator operations.

TASK FORCE ORGANIZATION

Primary Group

William Thompson*	DER - Air Quality Control
Blaine DeHaven	DER - Air Quality Control
John Egan	DER - Air Quality Control
Norman Glazer	Philadelphia - Air Management Services
Rao Kona	DER - Air Quality Control
John Knauber	DER - Air Quality Control
Doug Lesher	DER - Air Quality Control
Hartwin Weiss	DER - Air Quality Control
Deborah Woltjen	EPA - Air Management Division

Agency Records Review Team

Rao Kona*	DER - Air Quality Control
James Keil	DER - Air Quality Control
Richard Ruhl	DER - Air Quality Control

Plant Records Review Team

Hartwin Weiss*	DER - Air Quality Control
Doug Lesher	DER - Air Quality Control

On-Site Observation Team

John Egan*	DER - Air Quality Control
James Keil	DER - Air Quality Control
Doug Lesher	DER - Air Quality Control
John Pitulski	DER - Air Quality Control
Diane Simini	Philadelphia - Air Management Services
Deborah Woltjen	EPA - Air Management Division

Literature Review

John Knauber*	DER - Air Quality Control

*Coordinator

I. AGENCY RECORDS REVIEW

Finding #1 - During the twenty-four years that the Northwest Incinerator has been utilized as a trash disposal facility, several flyash collection and combustion control improvements have been implemented to reduce and/or maintain the emission of particulates and odorous gases to compliance levels.

Discussion- The significant air pollution control initiatives that have been previously implemented are summarized below:

Flyash Collection Improvements

1. Replacement of the original cyclone collectors with electrostatic precipitators.
2. Installation of baffles at the precipitator inlet to improve gas distribution.
3. Installation of additional water sprays between the combustion chamber and the cooling towers to improve furnace exhaust gas temperature control.
4. Rebuilding of the gas cooling and drying towers to improve performance and reliability.
5. Development of a new Operation and Maintenance Manual for the precipitators.

Combustion Control Improvements

1. Revision of operating procedures to avoid loss of the feed chute seal.
2. Installation of new furnace discharge chutes and an automatic water level control in the quench tank to prevent combustion upsets resulting from loss of the discharge chute water seal.
3. Relining of the furnaces to reduce air leakage and improve temperature control.

In addition to the above, the electrostatic precipitators were rebuilt to increase collection efficiency and taller stacks were erected to improve pollutant dispersion.

Trash and Residue Flow Improvements

1. Installation of warning lights to signal seal breaks in the feed hopper.
2. Modification of cooling tower bottoms to prevent water seal breaks.
3. Rebuilding of the residue conveyors to reduce breakdowns.
4. Purchase of new residue trucks to improve residue loadout.

Finding #2 - The results of numerous stack tests conducted during the past ten years to determine particulate emission concentrations indicate several exceedances of the compliance standard.

Discussion - The results of particulate emission testing conducted at the Northwest incinerator since 1976 are listed in the table on the following page.

STACK TEST RESULTS

PARTICULATE EMISSION CONCENTRATIONS

Test Date(s)	Unit	**Results at 12% CO_2
June 22-24, 1976(1)	1	.0398 gr/DSCF
Air Management Services	1	.0458 gr/DSCF
	2	.0469 gr/DSCF
	2	.0567 gr/DSCF
May 25 - June 1, 1978(1)	1	.1189 gr/DSCF
Air Management Services	1	.1201 gr/DSCF
	2	.3608 gr/DSCF
	2	1.1500 gr/DSCF
December 19, 1978(1)	1	.1367 gr/DSCF
Air Management Services	2	.1100 gr/DSCF
January 31, 1979(1)	2	.0443 gr/DSCF
Air Management Services		
June 28 - July 3, 1979(1)	1	.0484 gr/DSCF
Air Management Services	1	.0478 gr/DSCF
	2	.1045 gr/DSCF
	2	.0355 gr/DSCF
December 1-8, 1980	1	.1034 gr/DSCF
Engineering Science	1	.1074 gr/DSCF
	1	.1560 gr/DSCF
	2	.0471 gr/DSCF
	2	.1008 gr/DSCF
	2	.0475 gr/DSCF
*August 5-7, 1981	1	.052 gr/DSCF
Engineering Science	1	.059 gr/DSCF
	1	.039 gr/DSCF

*Measured ESP efficiencies during these three (3) tests varied from 95.8% to 96.1%.

**AMS STD. for compliance is .10 gr/DSCF at 12% CO_2. (Reg. XI, Section III(a)).

(1)Incinerator operating data not available for these tests.

Finding #3 - Ambient odor problems have been significantly diminished.

Discussion - Improved housekeeping and general operations, e.g., better maintenance of feed chute and residue discharge seals, have diminished odor problem complaints. Very few odor complaints have been received since mid 1983.

Finding #4 - Measured concentrations of the 2,3,7,8-TCDD dioxin isomer in flyash samples taken from the #1 furnace in early August 1984 were found to be higher than expected.

Discussion - The results of 2,3,7,8-TCDD dioxin testing conducted at the Northwest incinerator on August 1 and 2, 1984 are summarized below:

LEVELS OF 2,3,7,8-TCDD IN ASH SAMPLES*

Date	Furnace #	2,3,7,8-TCDD-ppb
8/1	1	28.2
8/1	2	3.2
8/2	2	3.4
8/2	1	16.7
8/2	2	4.4
8/2	1	23.0

*Taken from sampling and analysis report prepared by Engineering Science.

II. PLANT RECORDS REVIEW

The following records were reviewed:

1. Circular Charts (Units 1 and 2, August/September/October, 1984)
    - Furnace Temperature
    - Precipitator Inlet Temperature
    - Furnace Draft
    - Inclined Stoker Speed
2. Precipitator Data (hourly readings, same period as #1 above)
    - Primary Voltage
    - Primary Current
    - Secondary Current
3. Preventative and Corrective Maintenance Log for 1982, 1983 and 1984
4. Operation and Maintenance Manual

Finding #5 - During August, September, and October, 1984, the two units provided for a combined 128 operating days (unit #1 was not operating for the second half of October). Over 80% of the operating days (103) contained reports of a total of 320 upset conditions

	Number of Occurrences
1. Wet Rubbish	82
2. Hopper (jam-ups or empty unrelated to crane operation)	80
3. Crane Operation (malfunction or operator absence)	57
4. Other (restarts, emergencies, fan problems, etc.)	41
5. Conveyor	34
6. Precipitator	15
7. Trucks	11
Total	320

Discussion

The primary objective of the plant records review was to determine the type and frequency of operating problems occurring at the incinerators. The data and information contained in this finding focuses upon the above parameters and should not be interpreted as directly proportionate to the cumulative upset time resulting from the widely variable duration of the identified upset conditions.

1. Wet Rubbish Problems

This problem, accounted for more than a quarter of all upset conditions. The operating log does not indicate efforts are undertaken to mix wet rubbish with dry rubbish. Operating adjustments are apparently not properly utilized to prevent or remedy combustion problems resulting from wet trash, e.g., the inclined stoker speed is not used to compensate for unusual conditions by speed adjustments. Instead, the stoker speed almost always is maintained at a constant setting. It is totally shut off when furnace temperature is too high which would cause gaps in the refuse rather than a thinner bed.

The following example illustrates the problem. Monday, August 6, 1984, start-up occurs for both units with wet rubbish, 1400°F is not reliably reached for Unit #1 in 17 hours and for Unit #2 for 12 hours. The incline stoker for #1 was shut down four times during the first two hours and ran for the remaining time between 64 and 68 fph. The #2 incline stoker was shut down once during the first hour and rant at a constant 75 fph for the remaining time.

2. Hopper Problems

Upset conditions caused by low trash levels in the feed hoppers, empty feed hoppers and jammed feed hoppers were frequently recorded. The above conditions cause breaks of the feed chute air seal and voids on the furnace grate.

Lack of trash in the feed hopper indicates operator absence or improper use of the pit as a buffer.

Jamming problems were often reported to have been caused by large objects like refrigerators, metal doors, and other items which should be separated prior to charging. Stress to cranes and stokers caused by such objects will promote frequent failures of such mechanical equipment. The problem is compounded by the use of the crane grapple as a ramming device to force trash through the hopper. The grapple has been reported stuck inside the hopper. This condition aggravates the jamming problem and is potentially damaging to both the grapple and the hopper.

3. Crane Operating Problems

Cranes are recognized as being subject to frequent breakdown in this type of operation and, therefore, require a great deal of preventative maintenance and care. Crane problems will have an effect on the operation only in case of simultaneous breakdown of both units or operator absence, both of which make this the third most frequent cause for upset conditions.

4. Other Problems

This area covers a variety of malfunctions (restarts, fans, emergencies, etc.). There were 21 occasions (other than after weekends) that an incinerator had to be restarted after the fire was allowed to go out. Restarts can give rise to excessive emissions of air contaminants. Many of these problems appear to be related to operational and maintenance practices.

At the present time, operational and maintenance practices are such that corrective action is frequently required after an unusual event has taken place. The records do not document that preventative actions (i.e., slowing of stoker speed in response to a decrease in temperature is at or below critical levels) are undertaken.

5. Conveyor Problems*

A review of the operator logs indicates that three areas of concern need to be addressed relative to residue conveyors.

a. Winter time breakdowns are frequently caused by freezeups after weekend shutdowns.

b. On several occasions unburned rubbish resulted in residue conveyor jamming problems. Wet leaves are frequently mentioned in the logs as culprits.

c. Jamming caused by large objects is similar to that which causes feed hopper jammings and is often caused by the same objects.

6. Truck Problems*

These problems seem to affect incinerator operation when residue removal cannot take place. A disabled vehicle may block access or all vehicles may be disabled. The log books reveal a large number of breakdowns although only some cause operational problems for the incinerator.

7. Electrostatic Precipitator

These units may be considered oversized or overdesigned and capable of full control of a normally operated incinerator. The records show a relatively high degree of reliability. The logs do not, however, substantiate that preventative maintenance as required by the compliance agreement plan is taking place.

*As noted on page 4, the residue conveyor's were rebuilt and new residue tracks were purchased following the period covered by the plant records review.
On 15 of the total 128 operating days reviewed, precipitator problems of one type or the other were reported. Incinerator operations frequently continued during the time required to correct the precipitator problems. In August, the #1 precipitator "B" field was reported out for up to 8 consecutive days. The incinerator appears to have been operated during most of the time the "B" field was down.

III. ON-SITE OBSERVATIONS

Finding #6 - Operating conditions during the observed Monday morning start-up (following the routine weekend shutdown) were inadequate to achieve good combustion and resulted in excessive visible emissions.

Discussion - The #1 furnace was restarted at approximately 12:40 a.m. on December 3, 1984 following the weekend shutdown.

Prior to lightoff, the auxiliary systems (induced draft fan, residue conveyors, electrostatic precipitator, precipitator hopper heaters, insulator blower and flyash conveyor) were activated. Refuse was then fed to the charging hopper and the inclined stoker was run until the refuse reached the discharge end.

There is a free fall from the inclined stoker to the horizontal stoker of approximately 3 feet. An opening below the inclined stoker discharge provides access to this free fall area. The opening is about 8' wide by 2' high and is equipped with two loose fitting, free swinging metal flaps.

For light off, the flaps covering the above opening were opened and crumpled newspapers were inserted on the horizontal stoker grate below the discharge end of the inclined stoker. The newspaper was set on fire to ignite the refuse and the forced draft fan was turned on with the inlet dampers set in an almost fully closed position. The fire was allowed to spread up the inclined stoker before the stokers were turned on.

Refuse levels in the plants holding pits were very low. Wet leaves were a major constituent of the remaining material and, therefore, a large portion of the refuse fed to the unit at startup and for several hours thereafter consisted of wet leaves.

In the early stages of operation after light off, the operator had to continually check the fire through the rear view port and make adjustments accordingly. The speed of both stokers was gradually increased as was the volume of forced combustion air. The ID fan modulated automatically to maintain a relatively constant furnace draft. The

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operator started and stopped the inclined stoker and varied the speed of that stoker numerous times between light off and 2:00 a.m., at which time the speed was fixed at 66 feet per hour.

The precipitator inlet temperature reached 400°F within 20 minutes from light off and within 40 minutes of light off the precipitator inlet temperature stabilized at approximately 560°F. It required one hour and 10 minutes from light off for the furnace temperature to reach 1400°F.

One inspector observed the incinerator exhaust stack during startup. Darkness prevented reading accurate opacities, but it was observed that excessive smoking occurred during the first hour following light off.

Finding #7 - Bulky and/or non-typical trash items were frequently charged to the incinerator.

Discussion - Bulky and/or non-typical items, i.e., large pieces of furniture, mattresses, carpets, tires, etc. were frequently included in the refuse charged to the incinerator. Some of these materials resulted in diminished burning of localized areas of the refuse bed and appeared to contribute to the discharge of partially combusted and/or uncombusted materials from the furnace grate.

Finding #8 - Combustion of the refuse bed was observed to be incomplete and the residue discharged from the furnace grates contained significant quantities of unburned and/or partially burned trash.

Discussion - Failure to achieve effective burnout of the refuse bed appeared to be, in part, due to the limited mixing action inherent in the grate design. Observed charging procedures and stoker operating practices also appeared to contribute significantly to the burnout problem.

The clam shell buckets used for charging have a 3 yard^3 volume. However, it was typical for the bucket to pick up 1½ times its closed volume. During the 3 days of observation, the charging rate was 18.9 buckets/hr. Plant records indicate that the average mass charging weight for the week beginning December 3, 1984 was 15.9 tons/hr. These values yield a trash density of approximately 560 lbs./yd.^{3}, based upon a 3 yard^3 bucket volume. Given the >3 yard^3 actual pickup volume, it is reasonable to conclude that the actual trash density was somewhat less than the above value, but near the high end of municipal trash densities referenced in the literature. (Reference densities range from 270-540 lbs./yd.^{3}.)

The average grate loading, based upon the 15.9 tons/hr. charging rate, was 66.25 lbs./ft.^{2}/hr. Assuming an average refuse heating value of 4,400 BTU/lb., the calculated volumetric heat release for the furnace was approximately 15,000 BTU/hr./ft.^{3}. These grate loading and furnace heat release values are within accepted design limits for this type of incinerator. However, the above loading is considerably above the 40 lbs./ft.^{2}/hr. grate loading recommended by EPA in its "Field Surveillance and Enforcement Guide: Combustion and Incineration Sources" (APTD - 1449, 1973, pg. 9-3).

The most surprising observations were the thickness of the bed at the discharge end of the horizontal stoker and the large quantities of unburned and partially burned materials being discharged to the residue sump. Occasionially, the bed appeared to be as much as 4 feet deep and typically was at least 2½ feet deep at the point of discharge. At times, observers estimated that as much as 50% of the residue consisted of unburned refuse. It is important to note that the bed depth and trash burnout conditions described above depict refuse that had been in the furnace chamber for approximately 45 minutes.

As the residue was discharged from the stoker, newly exposed material would quickly flame up as if it had been starved for oxygen and it was obvious that some of the refuse was being totally insulated from combustion conditions. An automobile tire was observed in the residue that had apparently been buried on the grate in a standing position. The top portion was completely burned away to the reinforcing wires while the entire bottom section of side wall and tread remained totally intact. Plastic soda bottles which hadn't been burned or melted were observed in the residue along with partially burned newspaper, rags and branches.

Given the above conditions, it is possible that materials that could contribute to the formation or release of organic air contaminants may not be exposed to combustion conditions until just prior to discharge. Air contaminants released at this point may not be exposed to adequate retention time/temperature conditions for complete oxidation as the area at the discharge end of the stoker is also the shortest distance from the furnace gas exit and lies outside the normal flame path.

Finding #9 - Numerous large pieces of entrained refuse blown from the refuse bed or drawn from the stoker discharge area were observed to be incompletely combusted and still burning as they were exhausted from the furnace and entered the quench spray area.

Discussion - Velocity traverses were made during the observation inspections conducted on December 3, 4 and 5, 1984. The volumetric flow rates determined by these under normal operating conditions were consistent. The following flow rates are representative of these measurements:

Traverse Site	Volume SCFM
Exhaust Stack	67,000
Under fire air-inclined stoker	11,000
Under fire air horizontal stoker	19,000
Total underfire	30,000
Over fire	7,000
Wall cooling air duct	3,000
Total forced draft air	40,000
Unaccounted for induced air*	27,000

*Signficant quantities of air were drawn into the combustion chamber through the flaps beneath the inclined stoker. Other sources, e.g., the access door at the rear of the furnace, view ports, etc. were also noted. It is reasonable to conclude that the unaccounted for induced air entered from these sources and air leaks occurring in the system down stream of the furnace.

Calculation of an actual underfire to overfire air ratio is complicated by the uncertainties regarding air volumes induced through door flaps and other openings. Based upon the air volumes delivered by the forced fan system, the underfire to overfire air ratio would be in the range of 3.5:1 to 4.0:1. An underfire to overfire air ratio of 1:2 to 1:1, depending upon the moisture content of the refuse, is recommended by the reviewed municipal incineration reference literature. If it is assumed that 50% of the unaccounted for air is induced into the combustion chamber as overfire air, the underfire ratio would be reduced to approximately 1.25:1. This circumstance could not be confirmed from the available measurements or observations. Given the uncertainties resulting from the large volume of unaccounted for air, the actual underfire to overfire air could not be precisely determined. However both the values determined from delivered air rates and observations indicate the underfire to overfire air ratio may be signifinantly above the recommended range.

Theoretical combustion air for municipal refuse is, of course, dependent upon the combustibles content and composition of the refuse. Based upon typical municipal refuse composition and the 15.9 tons/hr. charging rate, it is reasonable to expect that the theoretical air requirement during the observed intervals was within the 15,000 to 20,000 scfm range. Based upon the above, fan delivered combustion air would represent aproximately 125% of theoretical air requirements. It is important to note that significant quantities of combustible materials were not burned, and excess air levels for the refuse actually undergoing combustion would therefore be significantly higher than the 125 to 150% range as determined by theoretical requirements for the refuse charged.

The average measured stack exhaust volume was measured to be approximately 67,000 scfmn. However, it is important to recognize that only 40,000 scfm was introduced to the furnace by the combustion air delivery system. A significant portion of this 27,000 scfm may have entered the system downstream of the combustion chamber and the workroom air that was drawn into the furnace through observed openings could not be considered overfire air and, at least in part, may not have been effectively available for combustion.

Finding #10 - Temperatures in the expanded section at the exhaust end of the combustion chamber were consistently maintained at levels above 1400°F.

Discussion - The operators were able to consistently maintain relatively high furnace temperatures, primarily by adjustment of both overfire and underfire air dampers. This was apparently a priority objective that overshadowed consideration of the other factors required for complete combustion.

The necessity to maintain required temperature levels was explained as the basis for not reducing stoker speeds during the frequent occasions when significant quantities of unburned refuse were being discharged from the discharge end of the stoker. (The records indicate that stoker speeds are sometimes reduced without loss of temperature, e.g., during the 12 to 8 shift on December 4, 1984 the recorded inclined stoker speed was 40 ft/ht and furnace temperatures were maintained within the 1500°F to 1700°F range.)

Gas mixing and retention time are also critical factors that must be considered to access the combustion effectiveness that can be achieved at a given furnace temperature level. The internal furnace configuration does not appear to provide the turbulence needed to achieve good mixing of the combustion gases and the actual flame pattern inside the furnace appeared to follow a nearly straight line from the stoker to the furnace exhaust gas exit.

Finding #11 - Particulate emissions appeared to be well controlled.

Discussion - With the exception of the previously noted start up emissions, visible emissions appeared to be minimal at the stack exit, although a light colored emission could be seen trailing off from the dissipating steam plume. Precipitator performance is undoubtedly enhanced by the low gas velocity through the collector. (The actual average flow rate of approximately 168,000 acfm is well within the 219,300 acfm design capacity.) The effective gas conditioning provided by the quench sprays also contributes to the good performance of the particulate emission control system.

No significant precipitator operating or maintenance problems were observed during the on-site inspection.

IV. LITERATURE REVIEW

Finding #12 - The studies published in currently available literature indicate that emission of dioxins and furans from municipal incinerators can be controlled to a level that is protective of public health by controlling temperature, retention time, combustion air and the turbulence of the gas stream within the combustion chamber.

Discussion - The references reviewed for toxic emissions from municipal refuse incineration are listed on Page 17.

Municipal waste incineration and potention emissions are extensively reviewed in the "Hart Report," which was prepared by a consultant for the New York Department of Sanitation. This study was undertaken as a result of New York's proposal to construct an incinerator at the Brooklyn Navy Yard.

Incinerator operating conditions and resultant emissions are also detailed in the Pilot Study Information of Specific Compounds from Combustion Sources.

Several studies of European resources recovery incinerators have also been published. However, the reports of this work that were available for review do not contain complete operating conditions and sampling procedures information.

The above studies indicate that combustion gas temperatures in the 1600°F - 1800°F range maintained for approximately two (2) seconds is sufficient for destruction of dioxin and furans, provided adequate gas mixing and proper oxygen levels are also maintained. These conditions cannot be maintained if waste fuel feed rates are too high to achieve effective combustion.

Finding #13 - High efficiency collection of particulate emissions may be required to control dioxin and furan compounds that are condensed on flyash particles.

Discussion - It has been suggested that the apparently high absorption of dioxin and furans on the surface of flyash particles may be a key factor in the control of these substances. The condensation/absorption of dioxin is increased as the gas is cooled to the 500°F - 700°F range.

Finding #14 - Insufficient data is available to quantitatively relate operating conditions to dioxin emission rates or guideline ambient concentrations.

Discussion - The ambient guideline for dioxin adapted by the City of Philadelphia is 35 pg/M^3. The results of stack tests conducted in early 1985 to determine dioxin emissions should provide the data required to evaluate the level of destruction and/or collection achieved, and any impact upon ambient levels.

RECOMMENDATIONS

Recommendation #1 - Perform an accurate assessment of the weight and volume of refuse being charged to the units and the weight and volume of residue being discharged from the units over a given period of time while operating utilizing current practices.

The operating practices identified by this study appear to be directed at feeding refuse at fixed predetermined stoker speeds and maintaining combustion chamber temperatures within certain parameters irrespective of residue burnout. As a result, poor burnout - i.e., weight and volume reduction of the refuse was observed. The information obtained should be used as a baseline for comparison with similar assessments to be conducted following implementation of modifications to current furnace firing procedures as recommended herein.

Recommendation #2 - Implement changes in the furnace firing procedures aimed at achieving maximum refuse burnout while maintaining combustion chamber temperatures above 1600°F. Refuse feed rates, stoker speed rates and overfire and underfire air distribution settings should be adjusted to optimize furnace combustion conditions while achieving proper refuse burnout. (Proper refuse burnout should yield a trash to residue weight rate reduction in the range of 70 to 75%.)

Incomplete refuse burnout contributes to less than optimum furnace combustion conditions regardless of furnace chamber temperatures and could contribute to the formation of organic air contaminants. During the study observations it was noted that due to high furnace grate loadings some materials were being totally insulated from combustion conditions until the actual point of discharge from the furnace.

Recommendation #3 - Identify air infiltration points and associated volumes. To the degree feasible, eliminate significant air leaks.

Traverses conducted as a part of the on-site evaluation determined that the stack exhaust to be approximately 27,000 scfm greater than the volume attributable to delivered air, moisture evaporation and combustion products. Air supply measurements were limited to delivered air and the distribution of leaked air entering through openings/leaks in the combustion chamber and/or downstream of the furnace exhaust is not known. This information and control of infiltrated air is important to further assessment of combustion conditions and adjustment of the parameters identified in Recommendation #2.

Recommendation #4 - Undertake a study to determine the feasibility of physically modifying the furnace and overfire injection system to increase residence time and turbulence in the combustion chamber.

The current furnace design does not include a gas mixing or secondary combustion chamber and the current overfire air distribution system does not appear to provide good mixing of the combustion gases. Adequate gas mixing and retention time are required to significantly improve furnace exhaust gas oxidation.

Recommendation #5 - Implement improved measures to control the type of material deposited and the segregation of waste in the refuse pit.

Large bulky non-combustibles (water heaters, refrigerators, etc.) and difficult to burn materials (grass clippings, wet leaves, etc.) should be excluded from the trash to the maximum extent possible. These items should be diverted to alternative disposal facilities, i.e., landfills, composts.

Combustion and/or charge chute jamming problems result from the current practice of dumping large, bulky combustibles such as sofas, mattresses, etc. directly into the refuse pit. These items should be diverted to a landfill or pre-processed in a shredder.

The trash pit frequently contains segregated deposits and the existing stoker design does not provide significant mixing of the refuse in the furnace. It is, therefore, important that pre-mixing be implemented to achieve a more homogenous distribution of the feed refuse. Improved refuse distribution can be accomplished by utilizing the charging bucket to more thoroughly mix the waste in the pit.

Recommendation #6 - Install a CEM to monitor visible emissions in accordance with DER provisions.

The above equipment is needed to monitor and evaluate smoke emissions. This capability is particularly important to assess emissions during startups, restarts and upset conditions.

Recommendation #7 - Discontinue the current practice of shutting the incinerator down over the weekend.

There are several problems associated with shutting the incinerator down on the weekend. These include cold conditions at startup, smoke emissions during restart, thermal shock to the equipment and low refuse levels in the pit that are more likely to consist of wet materials that sink to the bottom, e.g., wet leaves. Continuous operation for longer periods (30 to 60 days) would greatly reduce the above problems and may be required if implementation of Recommendations #1 and #2 results in reduced charging rates. The operational cost increase may be, at least in part, offset by reduced residue disposal costs resulting from improved burnout.

Recommendation #8 - Place increased emphasis upon proper crane operation and charging practices.

The crane operator should avoid charging the items identified in Recommendation #5. In addition to previously identified problems, these items have caused jamming of the charging chute, combustion upset and breakdowns. These circumstances have sometimes been exacerbated when the clam shell was used as a ramming device to drive jammed material through the chute. Efforts should be undertaken to assure that reasonably dry refuse is available for startup and vigilance of the refuse level in the charging chute should be maintained to assure that the feed seal is not broken.

Recommendation #9 - Implement timely operational adjustments to minimize air contaminant emissions following the occurrence of process upsets and/or equipment breakdowns.

Failure to undertaken appropriate actions to reduce air contaminant emissions during upset/breakdown conditions was noted during review of plant records. Continued operation of the furnace at the normal rate during periods when the residue removal system was down and continued operation of the furnace during precipitator field outages are examples of this problem.

Recommendation #10 - **Place greater emphasis upon preventative maintenance to reduce breakdowns.**

Scheduled maintenance as outlined in existing maintenance manuals should be continued. In addition, increased emphasis should be placed upon preventative checks of equipment known to be subject to breakdown (charging cranes, residue removal system trucks and precipitators). For example, one of the charging cranes is usually sufficient to maintain required feed rates, permitting alternation of use each shift or day. This circumstance provides an excellent opportunity to routinely inspect and maintain both cranes when they are rotated to standby status. Warning signs, i.e., unusual observations, sounds and instrument readings, should be used whenever possible to undertake corrective action before actual breakdown occurs. If the recommended seven days/week operation is implemented, periodic shutdowns should be scheduled to provide for inspection and maintenance of all system components.

Recommendation #11 - **Implement an ongoing combustion principles and practices training program for supervisor and operators.**

This training is important to the development of skills and abilities directly related to the primary objective of plant operations, i.e., good combustion of municipal refuse.

References

1) Principles & Practices of Incineration, edited by Richard Corey, John Wiley & Sons, Inc., 1969.

2) Solid Wastes, Origin, Collection, Processing and Disposal, C. L. Mantell, John Wiley & Sons, Inc., 1975.

3) Municipal Incineration, A Review of Literature, U.S. EPA - AP-79, James Stear, 1971.

4) Field Surveillance and Enforcement Guide: Combustion and Incineration Sources, U.S. EPA - APTD-1449, Devitt, Gerstle & Kulujian, 1973.

5) Inspection Manual for Envorcement of the New Source Performance Standards, U.S.EPA - 340/1-75-003.

6) Assessment of Potential Public Health Impacts Associated with Predicted Emissions of Polychlorinated Dibenzo-Dioxins and Polychlorinated Dibenzo-Furans from the Brooklyn Navy Yard Resource Recovery Facility, Fred C. Hart Associates, New York, New York for New York City Department of Sanitation, 1984.

7) Technical Conference on The Burning Issue of Disposing of Hazardous Wastes by Thermal Incineration, Air Pollution Control Association, April 1982.

8) Human and Environmental Risks of Chlorinated Dioxins and Related Compounds, Edited by R.E. Tucker, A. L. Young, and A. P. Gray, Plenum Press, New York, 1983.

9) Pilot Study of Information of Specific Compounds from Combustion Sources, C.L. Haile, J.S. Stanley, R. M. Stanley, R. M. Lucas, D. K. Milroy, C. P. Nulton, W. L. Yauger, EPA Contract No. 58-01-5915, 1983.

10) EPA Dioxins - EPA-600/2-80-197, November 1980.

11) Report of the Citizens Task Force on Resource Recovery in New York State, April 1984.

12) Environmental and Economic Analysis of Alternative Municipal Waste Disposal Technologies, Commoner, B., Shapiro, K., and Webster, T., Center for the Biology of Neutral Systems, Queens College, CUNY, Flushing, New York, May 1984.

APPENDIX A

OBSERVATION PROCEDURES

The Northwest Incinerator facility includes two combustion chambers with identical design features and capacities. The #1 furnace was selected for the purpose of conducting on-site evaluations of operating practices. Typically five team members were on-site during the observation periods. Assignments were rotated intermittently to increase familiarity with the overall process. During the first day of observation and a portion of the second day a sixth team member was also present for the purpose of off site observation of visible emissions.

The first individual was positioned on the charge hopper floor and counted every load delivered to the #1 furnace feed hopper throughout the observation shift. This individual also made notes regarding the time that the charge took place, any unique materials included in the charge and provided an estimate of the volume of the charge in terms of a closed bucket volume.

The second individual was located at the #1 furnace control panel on the stoker floor level of the incinerators. This individual recorded the readings from each instrument on the control panel at 15 minute intervals. Along with the panel readings this observer also checked and recorded the various windbox damper and overfire air duct damper positions and intermittently observed the conditions inside of the furnace through the two available viewports. Notes were made regarding the general atmosphere inside of the furnace including flame pattern and flame position along the horizontal grate, entrained flyash, excessive smoke, the depth of the burning refuse bed and any unique items observed in the bed. Intermittently this individual would also walk out on the platform above the residue troughs and conveyors and observe and make notes regarding the condition of the residue.

Individuals 3 and 4 were responsible for conducting the various velocity traverses performed in each of the combustion air delivery ducts, the wall cooling air delivery duct and in the furnace exhaust stack. The traverses were performed using a calibrated S type pitot tube and a liquid manometer. Each of the traverses was done according to the EPA Method 1 requirements. These individuals also performed Orsat and Fyrite analyses on exhaust gas samples at a location in the breeching connecting the furnace outlet and the first quench tower inlet downstream from the quench spray nozzles.

Individual #5 supervised and coordinated the other team members and spent considerable time observing, evaluating and making notes regarding general overall aspects of the facility equipment and operation, spent time discussing the operations with plant personnel and staff members from the City Streets Department, filled in for other members as necessary, performed additional Fyrite analysis on the furnace flue gas, physically inspected the operation of the electrostatic precipitator and spent considerable time looking at the refuse being charged, looking inside the incinerator, looking at the residue being discharged from the unit and observing the stack discharge for visible emissions.

As mentioned previously, the sixth individual, when available, performed off site visible emissions observations.

Most of the operating data presented in this report was obtained direcltly using on-site and/or DER instrumentation. The design data (capacities, dimensions) and certain operating data (weight rate charged, quench water flows) were obtained from plant representatives.

APPENDIX B

FACILITY DESCRIPTION

The facility includes two identical Tynan continuous feed, refractory-lined incinerators. Construction of the facility was completed in 1960. In 1974, electrostatic precipitators were retrofitted onto each of the furnaces. The facility is reported to handle only municipal refuse and each unit is currently rated to handle 375 tons per day. Waste is charged to the furnaces from either of two 500 tons holding pits to overhead cranes equipped with clam shell-type buckets.

Stokers

Each furnace is equipped with a water cooled gravity feed charging chute and two travelling grate stokers.

grate area -

The feed stoker is inclined 20° from horizontal and measures 22 feet in length by 8 feet in width. The second stoker is the horizontal stoker measuring 40 feet in length by 8 feet in width. The combined effective grate area for each furnace is 480 $feet^2$.

stoker speed -

The speed of the inclined and horizontal stokers can be independently varied. A speed range of 12 to 100 ft./hr. is reportedly available for both stokers. The speed of the inclined stoker determines the feed rate to the incinerator and the speed of the horizontal stoker determines the depth of the burning refuse bed.

The speed of the inclined stoker is continuously recorded by a circular chart recorder located on the furnace control panel, while a speed gauge for the horizontal stoker is located near the discharge end of the furnace. The speed rate settings of both of the stokers must be manually adjusted.

Combustion Chamber

Each furnace consists of a single combustion chamber approximately 55 feet long by 8 feet wide. From the feed end the first 34 feet of the chamber measures roughly 17½ feet in height above the surface of the horizontal stoker grate. The roof of the chamber then increases to a height of over 30 feet above the horizontal stoker grate for the remainign 21 feet of the length of the furnace. Exhaust gases leave the combustion chamber through an opening on the upper rear wall measuring 12 feet, 8 inches high by 8 feet wide. The total furnace combustion chamber volume is reported to be 9,360 $feet^3$. A sketch of the furnace is attached.

Combustion Air

Combustion air is provided by a single forced draft fan rated to deliver over 50,000 SCFM at 4½ inches static pressure. Three separate ducts deliver the air from this fan to different zones in the furnace. One supplies underfire air to the inclined stoke, one supplies underfire air to the horizontal stoker and one supplies to the overfire air system.

There is a pneumatically controlled louver-type inlet damper on the forced draft fan which is activated by a manual switch on the furnace control panel. A draft gauge on the furnace control panel which indicates the forced draft static pressure. The furnace operator varies the total combustion air flow rate by adjusting the control switch damper position.

underfire air -

There are individual dampers on each of the four air zones under the inclined stoker and on each of the six air zones under the horizontal stoker. By manually changing these damper positions, the operator can control the quantity of combustion air being delivered to any grate area thereby adjusting the actual location of the fire in the furnace as well as to some degree the intensity of the fire.

At one time, there were individual draft gauges for each of the horizontal stoker underfire air zones. These are now all inoperable. The operators only reference, other than the total combustion air draft gauge, is to visually observe the fire and adjust the windbox dampers accordingly based upon experience.

overfire air -

The overfire air system includes three delivery ducts each of which feeds a series of seven approximately 4" diameter feed pipes distributed in three rows in the roof of the lower first section of the combustion chamber. The first two rows are located above the inclined stoker while the third row is located over the beginning of the horizontal stoker. Each of the three overfire air delivery ducts has a manually adjustable damper which is set in either the full open or full closed position.

Originally, there were additional overfire air injection ports located in both side walls of the furnace about 1½ - 2 feet above the horizontal stoker grate. Refractory now covers the openings of these ports into the furnace and on one side, the delivery duct has been sealed.

auxiliary air -

These incinerators have air-cooled refractory walls, and all of the cooling air is being injected into the combustion chamber through 114 small (approximately 2½" inch dia.) openings located on both sidewalls of the stoker. The supply fans for the wall cooling system on each furnace are direct drive blowers rated to deliver 3600 SCFM at 6 inches static pressure. Since all of the wall cooling air ends up in the combustion chamber, it must be included as combustion air. The wall cooling fans run at all times and the operator makes no adjustments or variations to these systems.

Furnace Temperature Control

There are two separate thermocouples located on the upper side wall in the large rear section of the combustion chamber. These thermocouples monitor the combustion chamber temperature and are each tied to a continuous recorder, one a circular chart recorder on the furnace control panel and the other a strip chart recorder located in the plant superintendent's office. There are no automatic controls tied to these furnace temperature sensors. The operator must constantly monitor the temperatures on the circular recorder and decide what adjustments to make, if any, to the furnace controls.

Furnace Exhaust Gas

draft -

One of the few automatic controls on the furnace is a draft controller. The controller senses the furnace draft in the upper area of the combustion chamber and signals changes to the systems 400 HP variable speed induced draft fan. There is a draft gauge located on the furnace control panel as well as a circular chart recorder which provides a continuous record of the furnace draft. The automatic controller appears to be set to maintain the furnace draft within a range of approximately 0.2" H_2O. During typical operation the furnace draft is maintained at about 0.3 to 0.5" H_2O. Because the ID fan speed is constantly varying to maintain the draft, the fan motor amperage is monitored continuously and recorded on a circular chart recorder on the furnace control panel. It is also tied into a high current motor shut off to protect the motor.

cooling -

As the exhaust gases leave the furnace, they pass through a section of refractory-lined breeching connecting the furnace to the inlet of the first of two quench towers. A series of air atomized water spray nozzles are located in this breeching immediately following the furnace exit. These nozzles can provide up to 200 gpm for quenching the furnace exhaust gases. The actual water flow rate to the nozzles is controlled by another of the few automatic controls on the furnace. An array of thermocouples located in the duct at the inlet to the electrostatic precipitator, downstream from the quench towers, signals the controller to adjust the quench water spray rate to maintain a relatively constant precipitator inlet temperature. A circular chart recorder on the furnace control panel continuously records the precipitator inlet temperature and a continuous strip chart recorder on the control panel records the actual water flow rate. The precipitator inlet temperature is typically maintained at approximately 550°F. Excessive inlet temperatures will first sound an alarm and then shut down the system ID fan.

Flyash Collection

The incinerators are equipped with electrostatic precipitators to control flyash emissions. The precipitators on both furnaces are identical two-field units manufactured by Combustion Engineering. Design values for each unit are summarized below:

Collection plate area -	45,000 $ft.^2$
Volumetric flow -	219,000 ACFM at 550°F
Gas velocity -	4 ft./sec.
Gas reduction time -	6 seconds

The two quench towers which precede the precipitator were installed at the same time and provide adequate time for quenching the gases while also acting as precleaners removing much of the larger flyash particles exhausted from the furnaces.

Both fields of the precipitators are equipped with instrumentation for monitoring primary voltage, primary current and secondary current. The instruments are located on the furnace control panel and the furnace operator records all of the precipitator gauge readings hourly. There are also timer controllers located on the control panel for activating the precipitator rapping systems.

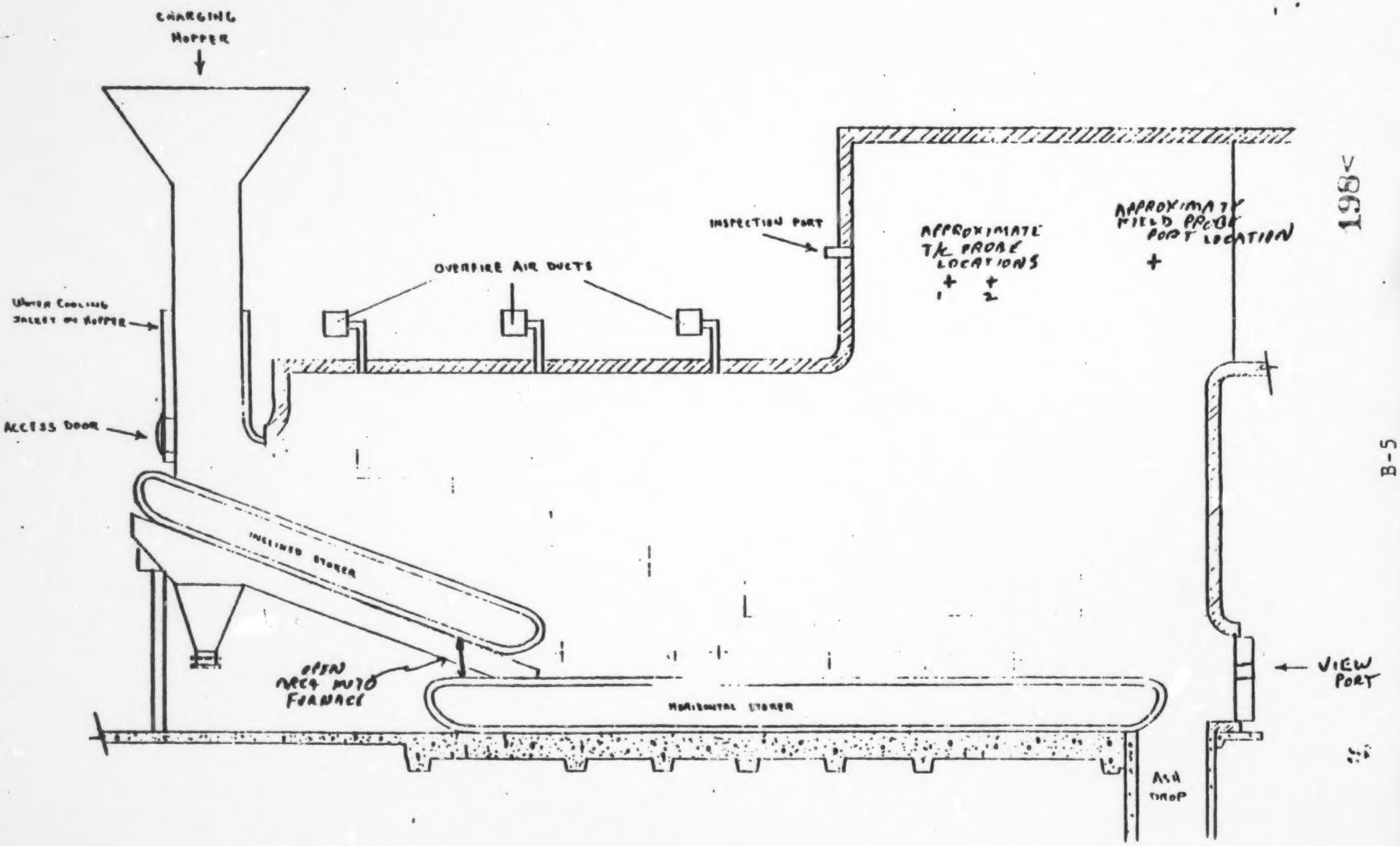
The collection hoppers in both precipitator fields are equipped with resistance heaters. Temperature controllers for these heaters are located on the furnace control panel. There is a single blower which provides preheated air from a resistance heater to the insulators on both fields of each precipitator. An ammeter is located on the furnace control panel for monitoring the insulator blower motor current.

Flyash/Furnace Residue Sump System

The flyash collected in the preicipitators is discharged via sealed drag conveyors and gravity chutes directly into the same wet sumps which receive the residue discharged from the furnaces. Gravity chutes located below the discharge end of the horizontal stokers terminate below the top of the water level in the wet sumps sealing the residue discharge area from the furnace draft. The quench towers are also equipped with wet bottom sumps which overflow into the main sump on each system.

The combined residue is pulled up an inclined drag conveyor from the bottom of the main sump and excess water from the residue drains back into the sump. The residue itself is discharged from the end of the drag conveyor into waiting 20 yard^3 residue receiving trucks. A dedicated number of these vehicles are kept on-site.

The residue and ash handling systems on each furnace are totally independent and material from one furnace cannot be diverted to the sump on the other, therefore, any extended breakdown on the residue system dictates a shutdown of the feed to that furnace. The plant discharges between 200-300 gpm of wastewater to the city's sewage system.


CHARGING HOPPER
WATER COOLING JACKET ON HOPPER
ACCESS DOOR
OVERFIRE AIR DUCTS
INSPECTION PORT
APPROXIMATE T/C PROBE LOCATIONS
1
2
APPROXIMATE FIELD PROBE PORT LOCATION
INCLINED STOKER
OPEN AREA INTO FURNACE
HORIZONTAL STOKER
ASH DROP
VIEW PORT

APPENDIX C

DATA AND CALCULATIONS

PHILADELPHIA NORTHWEST INCINERATOR TRAVERSE DATA

Reproduced from best available copy.

Date: December 3, 1984
Time: First Shift (12:00 A.M. - 8:00 A.M.)

RVN #1

Traverse Site	Traverse Time	Ave. Ts °F	Ave. Vs Ft./Min.	Volume ACFM	SCF
Exhaust Stack	2:51 A.M. - 3:19 A.M.[1]	486	48.0	108065	441
Under-Fire Horizontal Stoker	4:55 A.M. - 5:08 A.M.	43	53.0	19497	205
Over Fire Air Duct	4:21 A.M. - 4:35 A.M. [2]	45	17.0	6213	65
Under-Fire Inclined Stoker	3:59 A.M. - 4:15 A.M.	40	33.9	12441	1318
Wall Cooling Air Duct	3:30 A.M. - 3:45 A.M.	76	31.5	3365	332
					435

Date: December 4, 1984
Time: Second Shift (4:00 P.M. - 12:00 A.M.) First Series of Traverses

RVN #2

Traverse Site	Traverse Time	Ave. Ts °F	Ave. Vs Ft./Min.	Volume ACFM	SCF
Exhaust Stack	5:04 P.M. - 5:30 P.M.[3]	505	63.0	142074	5496
Under-Fire Horizontal Stoker	6:15 P.M. - 6:30 P.M.	37	50.4	18515	197
Over-Fire Air Duct	6:42 P.M. - 6:52 P.M. [2]	40	16.7	6124	64
Under-Fire Inclined Stoker	6:57 P.M. - 7:07 P.M.	40	25.8	9494	100
Wall Cooling Air Duct	7:17 P.M. - 7:23 P.M.	101	29.8	3182	300
					393

Second Series of Traverses

RVN #3

Traverse Site	Traverse Time	Ave. Ts °F	Ave. Vs Ft./Min.	Volume ACFM	SC
Exhaust Stack	9:03 P.M. - 9:36 P.M.	513	75.0	169547	674
Under-Fire Horizontal Stoker	10:04 P.M. - 10:22 P.M.	36	49.7	18279	195
Over-Fire Air Duct	10:37 P.M. - 10:49 P.M. [2]	37	17.7	6495	69
Under-Fire Inclined Stoker	10:56 P.M. - 11:07 P.M.	36	26.5	9755	104
				WC · AVG	30
					39

Date: December 5, 1984
Time: Third Shift (8:00 A.M. - 4:00 P.M.) First Series of Traverses

RVN #4

Traverse Site	Traverse Time	Ave. Ts °F	Ave. Vs Ft./Min.	Volume ACFM	SC
Exhaust Stack	8:49 A.M. - 9:26 A.M.[4]	493	66.0	148765	60
Under-Fire Horizontal Stoker	10:04 A.M. - 10:16 A.M.	38	47.4	17408	18
Over-Fire Air Duct	10:23 A.M. - 10:31 A.M. [2]	40	18.8	6919	7
Under-Fire Inclined Stoker	10:35 A.M. - 10:46 A.M.	40	27.9	10269	10
Wall Cooling Air Duct	10:54 A.M. - 11:01 A.M.	108	27.0	2900	27
					34

* ASSUMED AVG MOISTURE IN EXHAUST STACK @27% ([illegible] ; TES

NOTES ① F.D. FAN DAMPER POSITION SET TO 0 (MINIMUM) AT 2:55 A.M. - NEXT [illegible]

② F.D. FAN DAMPER POSIT. SET AT [illegible] NEAR 20 (MAX)

③ F.D. FAN DAMPER POSIT. 0 AT BEGINNING OF TRAVERSE INCREASED GRADUALL TO 16 BY END OF TRAV.

[illegible] AT 11 AT BEGINNING OF TRAVERSE, DECREA

Reproduced from best available copy.

Second Series of Traverses

RUN #5

Traverse Site	Traverse Time	Ave. Ts °F	Ave. Vs Ft./Min.	Volume ACFM	SCF
Exhaust Stack	1:20 P.M. - 1:43 P.M.	514	73.8	166351	6607
Under-Fire Horizontal Stoker	2:32 P.M. - 2:44 P.M.	39	41.3	15193	1613
Over-Fire Air Duct	2:52 P.M. - 3:02 P.M.	40	22.9	8401	896
Under-Fire Inclined Stoker	3:08 P.M. - 3:18 P.M.	40	30.4	11171	118
				WC AVG.	30
					39

② (bracketing the four traverse times)

* ASSUMED 27% MOISTURE AVG.

② F.D. FAN DAMPER POSIT. AT MAX SETTING OF 20.

The avg. fan delivered air to the combustion chamber (F.D. + wall cooling fan) with the F.D. fan at typical max. damper position (~20) and discounting #1 measurements (STARTUP) is 39,637 SCFM. The avg exhaust gas volume measured when F.D. fan was held in max. damper posit. was 66,749 SCFM. Leakage into the system under these conditions accounts for an avg of 27,112 SCFM

AVG. AIR RATIOS (DISCOUNTING #1 - START UP CONDS)

SCFM

TRAVERSE SET #	HORIZ AIR	INCLINE AIR	WALL COOLING	OVER FIRE AIR
2	19744	10064	3006	6491
3	19532	10424	–	6926
4	18527	10685	2706	7334
5	16137	11841	(3327)*	8905
AVG.	18485	10804	3013	7414

* FROM #1 TRAVERSE-

(ASSUME WALL COOLING AIR TO BE UNDERFIRE SINCE IT IS DELIVERED BELOW LEVEL OF REFUSE)

TOTAL UNDER AIR 32302 SCFM
TOTAL OVER AIR 7414 SCFM

RATIO OF UNDER TO OVER = 4.4/1

J.E.

SUMMARY OF DAILY CHARGING RECORD

Mon 12/3/84	ACTUAL	ESTIMATED
1:00-1:59 -	13	18.5
2:00-2:59 -	23	34
3:00-3:59 -	24	26
4:00-4:59 -	19	21
5:00-5:59 -	22	33.5
AVGS.	20.2 ld/hr	26.6 load/hr

Tue 12/4/84	ACT.	EST.
4:00-4:59	18	21
5:00-5:59	15	21
6:00-6:59	19	35 1/2
7:00-7:59	19	23
8:00-8:59	18	24.5
9:00-9:59	16	23.5
10:00-10:59	17	25
AVGS.	17.4 ld/hr	24.8 ld/hr

Wed 12/5/84	ACT.	EST.
8:30-8:59	11	14
9:00-9:59	14	20.5
10:00-10:59	20	33.5
11:00-11:59	22	35.5
12:00-12:59	19	29
1:00-1:59	20	34
2:00-2:59	18	27.5
AVGS	19.1 ld/	29.8 ld/hr

TOTAL BURN HRS WK OF 12/3 = 216.75
#1 = 111.5 hrs #2 = 105.25 hrs
AVG #1 load ≅ 51.4%

TOTAL BURN WGT FOR WK OF 12/3

12/3 742 TONS
12/4 820
12/5 699
12/6 572
12/7 685
12/8 -76 (compacted out)
3442 TON/wk

3442 x .514 ≅ 1769 Tons/wk to #1 FCE
1769 Tons ÷ 111.5 hrs = 15.9 ton/hr
= 31,800 lbs/hr

Actual hourly charge rates measured
12/3 - 20.2 chg/hr
12/4 - 17.4
12/5 - 19.1
3 ⟌56.7
18.9 chgs/hr avg

15.9 ton/hr × 1 hr/18.9 chg × 2000 lb/ton = 1683 lbs/c

#1 FURNACE

12/3/84

CONTROL PANEL READINGS

			PPTR "A" FIELD				PPTR "B" FIELD				
ME	ATR "A" HOPPER TEMP.	ATR "B" HOPPER TEMP.	PRIMARY VOLTAGE	PRIMARY CURRENT	SECOND. CURRENT	"A" SPARK RATE	PRIMARY VOLTAGE	PRIMARY CURRENT	SECOND CURRENT	"B" SPARK RATE	INSULATOR BLOWER CURRENT
	(°F)	(°F)	(VOLTS)	(AMPS)	(ma)	(SPM)	(VOLTS)	(AMPS)	(ma)	(SPM)	(AMPS)
:45	240	100	225	80	300	30	210	110	420	8	21.5
:00	225	100	210	75	290	30	220	90	400	8	22
:15	225	100	190	60	290	42	190	85	300	18	22
:30	220	100	190	90	320	16	190	110	420	12	21
45	220	100	210	85	320	26	185	125	400	8	22
00	230	100	200	130	360	36	175	120	420	5	21.5
15	220	105	200	115	400	30	180	110	440	14	21
30	220	110	210	115	420	24	190	110	400	5	21
45	220	110	225	110	420	30	185	105	390	12	21.5
00	220	110	225	110	400	30	185	90	390	30	21.5
15	220	110	225	115	420	30	185	10	190	32	21.5
:30	220	125	225	120	440	18	180	60	220	18	21.5
45	225	135	240	130	480	12	170	85	360	12	21
:00	230	135	200	70	320	34	185	65	305	24	22
:15	230	140	225	95	375	46	195	110	395	10	22
:30	230	150	235	100	395	30	195	95	395	28	22
:45	230	150	235	105	405	34	180	65	210	24	22
:00	230	150	245	155	505	30	195	75	360	8	22
:15	230	160	240	125	460	19	200	105	380	18	21
:30	220	160	230	90	400	26	190	75	360	24	21
:45	220	160	230	110	420	36	200	105	400	18	21

PHILA. N.W. INCINERATOR

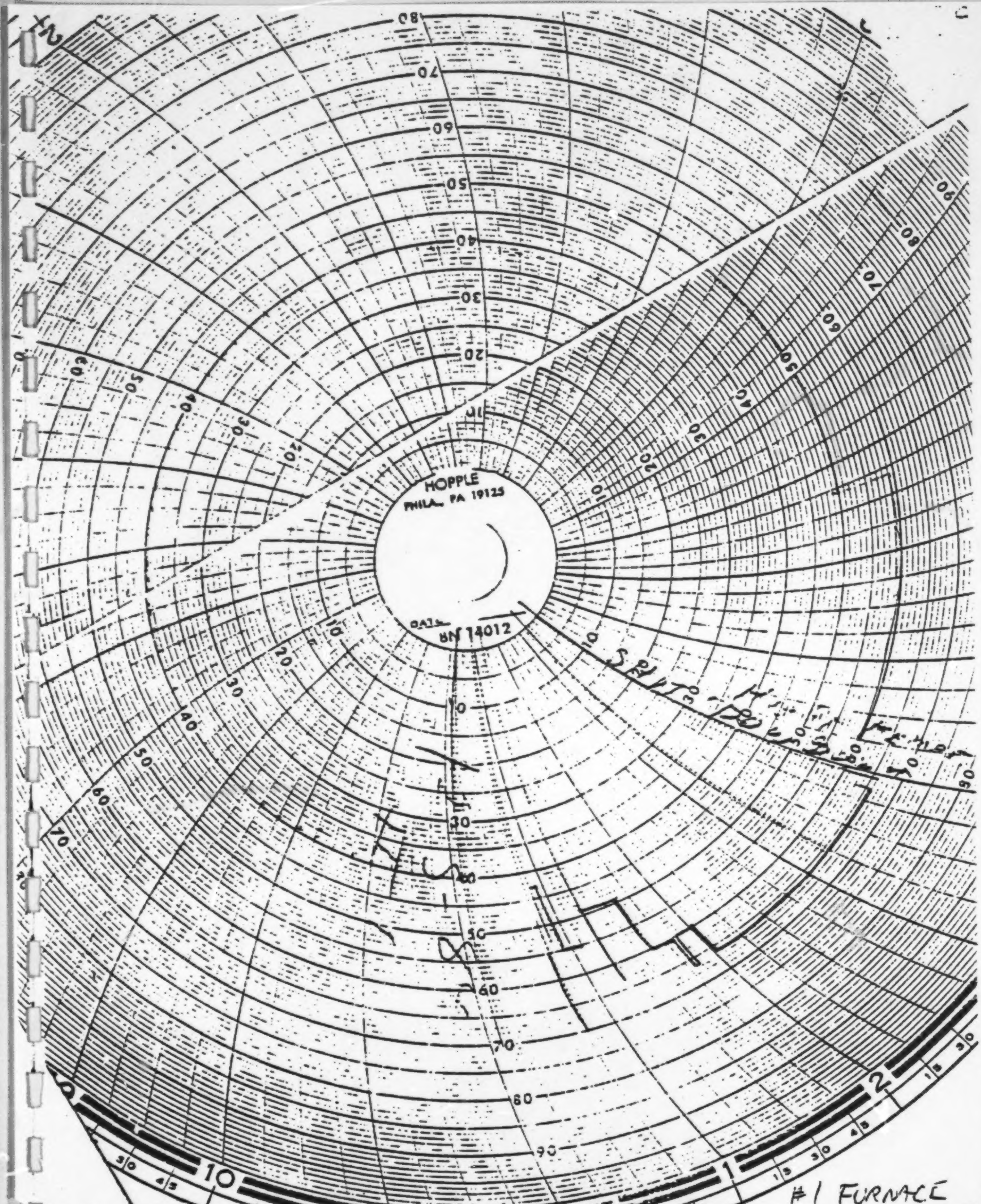
CONTROL PANEL READINGS

FURNACE

12/3/84

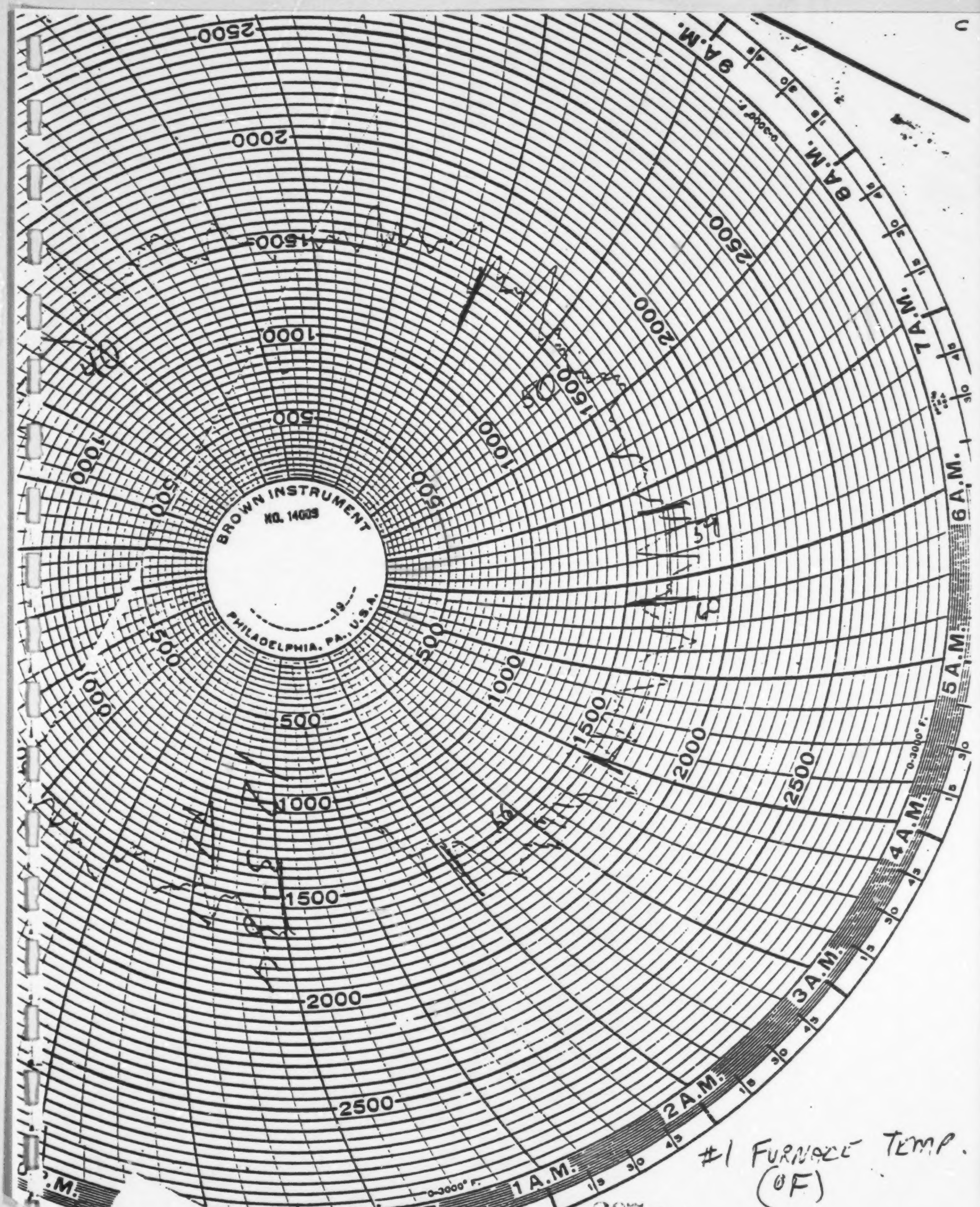
TIME	F.D. FAN CONTROL SETTING	FORCED DRAFT	FURNACE DRAFT	I.D. FAN CURRENT	INCLINE STOKER SPEED	HORIZ STOKER SPEED	FURNACE TEMP.	PPTR INLET TEMP	DAMPER POSITIONS *				QUENCH WATER FLOW RATE
									OVER FIRE	UNDER INCLINE	UNDER FIRE HORIZONTAL		
	(PSI)	(IN. H₂O)	(IN. H₂O)	(AMPS)	(FPH)	(FPH)	(°F)	(°F)	1 2 3	1 2 3 4	1 2 3	4 5 6	(GPM)
2:45 AM	3	1.5	0	65	0	60	300	—	C C C				20
1:00	3	1.75	-.1	80	55	65	900	450					10
1:15	3.5	1.75	-.15	100	49	60	940	490					20
1:30	16.5	2.5	-.1	140	50	60	1200	555	C C C	C 0 0 0	0 0 1/2	1/2 C C	30
1:45	19.5	2.5	-.1	140	67	60	1540	560					76
2:00	19.5	2.2	-.15	150	66	60	1390	555	C C C	C 0 0 0	0 0 1/2	1/2 C C	54
2:15	19.5	2.3	-.2	150	66	60	1440	555	C C C				56
2:30	0.5	1.7	-.1	160	66	60	1710	560					84
2:45	13.75	2.0	-.1	190	66	57.5	1700	560	O C O				90
3:00	0	1.7	-.1	150	65	68	1700	555					84
3:15	0	1.5	-.2	225	70	90	1700	575					100
3:30	0	1.6	-.1	175	65	85	1680	550	C C O	C 0 0 0	0 0 1/2	C C C	90
3:45	0	1.55	-.1	180	65	87	1800	550					110
4:00	20	1.9	-.3	180	60	87	1800	550	O O O	C 0 0 0	0 0 1/2	C C C	64
4:15	19.5	2.15	-.2	190	60	87	1550	555					48
4:30	19.5	2.1	-.3	220	60	87	1600	560	C O C	C 0 0 0	0 0 1/2	C C C	76
4:45	20	2.8	-.25	225	60	87	1550	560	C O C	C 0 0 0	0 0 1/2	C C C	90
5:00	20	2.7	-.25	180	60	87	1600	550	C O C	C 0 0 0	0 0 1/2	C C C	116
5:15	19.5	2.6	-.25	225	60	85	1660	555	C O C	C 0 0 0	0 0 1/2	C C C	94
5:30	19.5	2.1	-.25	250	60	85	1625	555	C O C	C 0 0 0	0 0 1/2	C C C	84
5:45	19.5	2.4	-.25	230	60	85	1600	560	C O C	C 0 0 0	0 0 1/2	C C C	78

* DAMPER POSITIONS (NUMBER DESIGNATES POSITION FROM FEED END



#1 FURNACE
INCLINE STOKER
SPEED (FT/HR)

206<



207<

#1 FURNACE TEMP.
(°F)

12/3/84

PHILA. N. W. INCINERATORS

12/4/84

CONTROL PANEL READINGS

TIME	ATR "A" HOPPER TEMP	ATR "B" HOPPER TEMP	PPTR "A" FIELD PRIMARY VOLTAGE	PPTR "A" FIELD PRIMARY CURRENT	SECOND CURRENT	"A" SPARK RATE	PPTR "B" FIELD PRIMARY VOLTAGE	PPTR "B" FIELD PRIMARY CURRENT	PPTR "B" FIELD SECOND CURRENT	"B" SPARK RATE	INSULATOR BLOWER CURRENT		
	(°F)	(°F)	(VOLTS)	(AMPS)	(mA)	(SPM)	(VOLTS)	(AMPS)	(mA)	(SPM)	(AMPS)		
4:00PM	220	150	260	130	500	6	200	70	280	30	21		
4:15	220	150	260	125	450	20	200	75	290	18	21		
4:30	220	150	230	125	500	20	190	75	320	24	21		
4:45	220	150	210	110	460	24	190	180	300	24	21		
5:00	240	155	250	130	520	4	190	65	250	12	21		
5:15	230	150	210	105	380	28	190	80	350	28	21		
5:30	230	150	250	110	400	32	190	80	320	32	21		
5:45	230	150	255	140	450	32	195	65	320	16	21		
6:00	225	160	250	115	450	22	195	75	300	30	21		
6:15	225	155	230	110	400	18	190	70	290	18	21		
6:30	225	160	250	115	340	20	200	75	260	30	21		
6:45	225	160	225	110	420	24	195	85	320	24	21		
7:00	225	160	240	110	400	26	200	75	280	12	21		
7:15	225	160	250	115	440	20	200	75	280	20	21		
7:30	225	160	250	110	420	24	200	85	320	20	21		
7:45	225	170	250	130	430	24	200	85	320	20	22		
8:00	225	165	250	130	440	28	195	50	200	31	22		
8:15	225	165	250	125	420	16	195	60	260	15	22		
8:30	225	165	250	120	450	22	200	70	270	14	22		
8:45	225	165	250	90	440	31	190	60	260	26	22		
9:00	225	165	250	120	450	18	200	85	300	20	22		
9:15	220	160	240	105	380	32	190	80	300	20	21		
9:30	220	165	250	110	420	24	200	70	280	20	21		
9:45	220	165	250	115	440	36	200	60	220	34	21		
10:00	220	165	250	110	440	26	200	80	320	20	21		
10:15	220	165	250	105	400	36	190	80	280	24	21		
10:30	220	165	220	125	460	12	190	100	400	12	21		
10:45	220	165	240	110	420	12	200	90	340	12	21		
11:00	220	165	240	110	400	12	180	60	220	8	21		

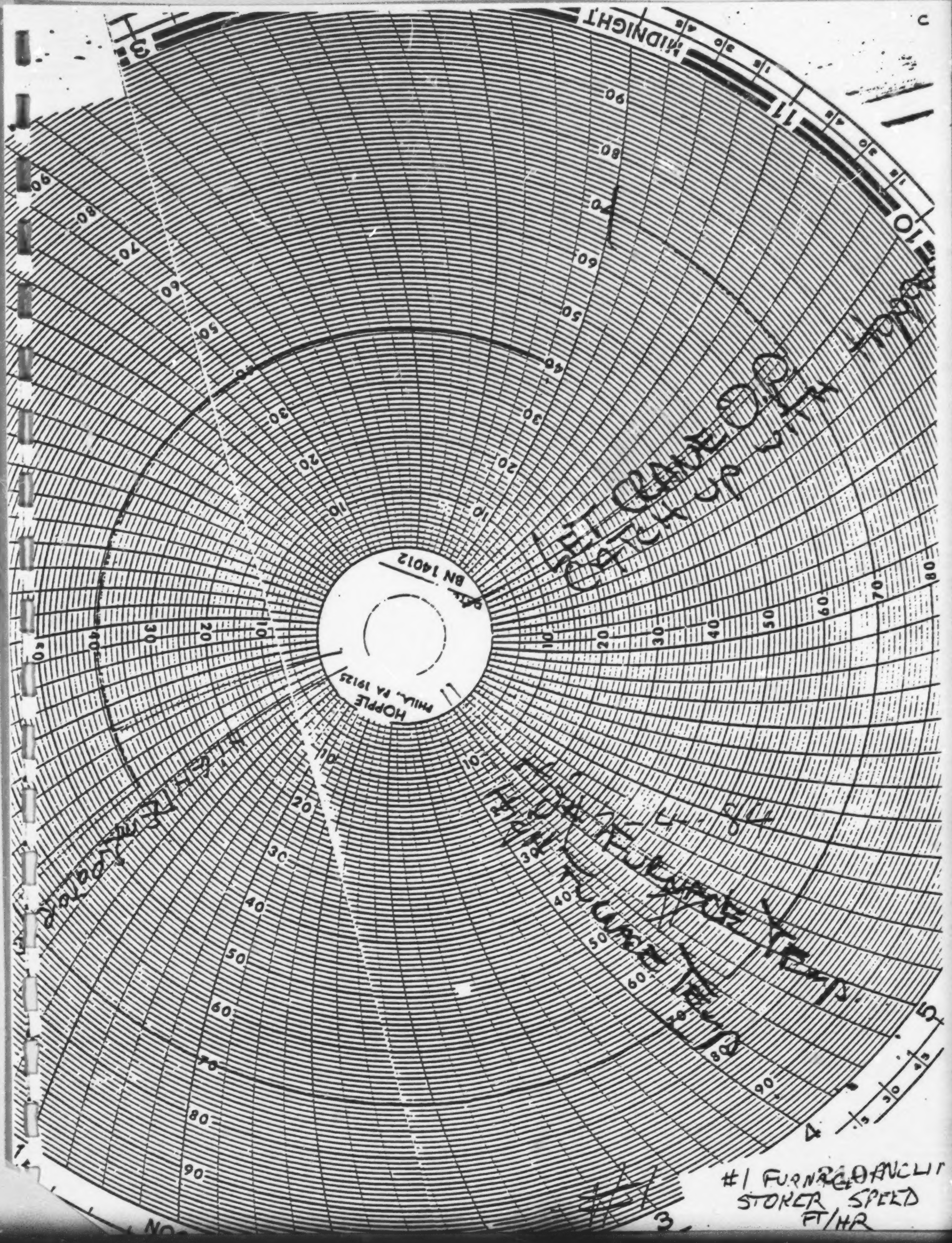
[illegible] #1 [illegible]

CONTROL PANEL READINGS

12|4|84

TIME	F.D. FAN CONTROL SETTING	FORCED DRAFT	FURNACE DRAFT	I.D. FAN CURRENT	INCLINE STOKER SPEED	HORIZ STOKER SPEED	FURNACE TEMP.	PPTE INLET TEMP	DAMPER POSITIONS * OVER FIRE	UNDER INCLINE	UNDER FIRE HORIZONTAL		QUENCH WATER FLOW RATE
	(PSI)	(IN. H2O)	(IN. H2O)	(AMPS)	(FPH)	(FPH)	(°F)	(°F)	1 2 3	1 2 3 4	1 2 3	4 5 6	(GPM)
4:00PM	19.5	2	.3	260	70	65	1850	555	0.00	C00 C	0 2/3 1/2	C 0 C	112
4:15	19.5	2	.3	250	70	65	1850	560	000	C000	0 1/8 2/3	1/2 C C	116
4:30	0	0	.25	100	70	65	1850	555	0.00	C000	0 1/4 1/3	0 C C	70
4:45	0	.5	.4	125	70	65	1700	555	000.	C000	1/4 0 3/4	C C C	70
5:00	0	1.7	.2	125	0	100	1800	555	000	C0 1/2 1/2	0 0 3/4	1/2 C C	150
5:15	6	1.3	.3	200	70	100	1725	555	000	C0 1/2 1/2	1/4 0 3/4	0 C C	40
5:30	16	1.9	.35	200	70	100	1625	555	000	C0 1/2 1/2	C 1/3 1/2	0 1/2 C	80
5:45	17.5	2.0	.33	250	70	100	1825	560	00C	C0 1/2 1/2	1/4 1/3 1/2	0 1/2 C	110
6:00	17.5	1.9	.3	265	70	100	1740	555	00C	C0 1/2 1/2	3/4 1/3 1/2	0 1/2 C	92
6:15	17.5	2.0	.35	250	70	100	1700	555	00C	C00 1/2	3/4 1/3 1/2	0 1/2 C	94
6:30	19.5	2.0	.3	300	70	100	1700	560	00C	C00 1/2	3/4 1/3 1/2	0 1/2 C	124
6:45	19.5	1.8	.3	250	70	100	1650	555	000	C00 1/2	3/4 1/3 1/2	0 1/2 C	74
7:00	19.5	1.8	.3	260	70	95	1675	555	000	C00 1/2	3/4 1/3 1/2	0 1/2 C	92
7:15	20	1.9	.35	225	70	100	1675	555	000	C00 1/2	C 1/3 1/2	0 1/2 C	96
7:30	19.5	1.9	.35	250	70	100	1700	555	000	C00 1/2	C 1/3 1/2	0 1/2 C	92
7:45	19.5	1.9	.35	275	70	100	1740	555	000	C00 1/2	1/4 1/3 1/2	0 1/2 C	100
8:00	19.5	1.9	.34	300	70	100	1810	555	000	C00 1/2	1/4 1/3 1/2	0 1/2 C	110
8:15	19.5	1.9	.4	280	70	100	1740	560	000	C00 1/2	"	"	96
8:30	19.5	1.9	.3	275	70	100	1730	550	000	C00 1/2	"	"	104
8:45	19.5	1.8	.35	275	70	100	1680	560	000	C00 1/2	"	"	70
9:00	19.5	1.9	.35	290	70	100	1700	560	000	C00 1/2	"	"	100
9:15	20	1.9	.3	275	70	82	1600	560	000	C00 1/2	"	"	76
9:30	20	1.8	.3	260	70	80	1625	560	000	C00 1/2	3/4 1/3 0	0 1/2 C	96
9:45	20	1.8	.3	280	70	82	1800	555	000	C00 1/2	"	"	110
10:00	20	1.8	.35	270	70	0	1750	550	000	C00 1/2	3/4 1/3 0	0 1/2 C	110
10:15	20	1.7	.37	225	70	80	1600	560	000	C00 1/2	"	"	40
10:30	20	1.7	.3	240	70	82	1650	550	000	C00 1/2	1/4 1/3 0	0 1/2 C	70
10:45	.18	2	.3	200	70	82	1650	550	000	C00 1/2	"	"	92
11:00	18	2	.375	250	70	82	1700	555	000	C00 1/2	2/3 1/3 0	0 1/2 C	90
A													

* DAMPER POSITIONS (NUMBER DESIGNATES



LET GRATE CATCH UP WITH TEMP

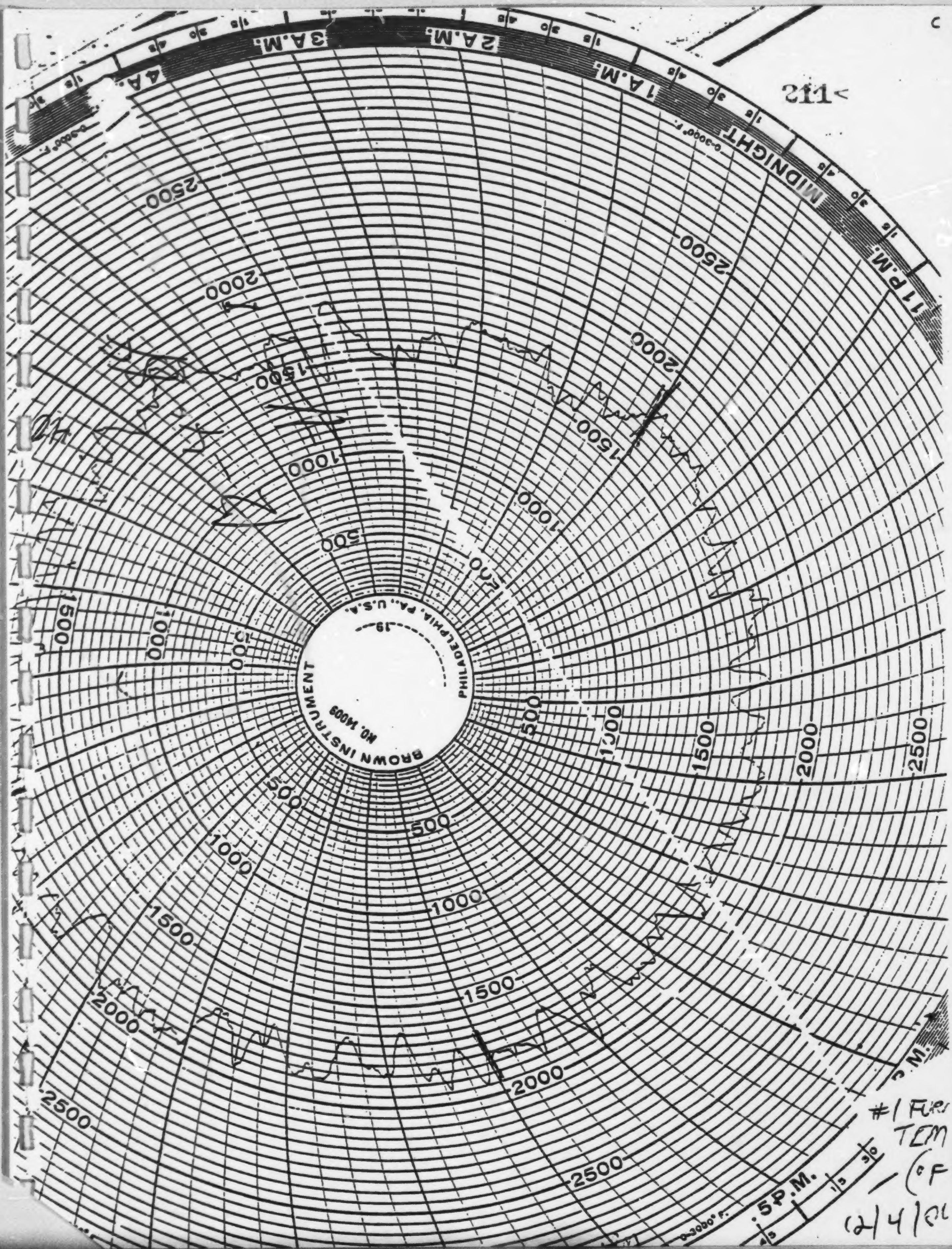
6-4-84

FURNACE TEMP

GRATE TEMP

CHK REGULATOR

#1 FURNACE
STOKER SPEED
FT/HR



#1 FUR
TEM
/ (°F
12/4/81

C

ER-AQ-39 REV. 8/79

Commonwealth of Pennsylvania
Department of Environmental Resources
Bureau of Air Quality Control

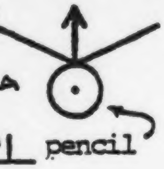
File No. NWI - AG

VISIBLE EMISSIONS OBSERVATION RECORD

Description of Source: N.W. INCINERATOR #1 UNIT STACK

Owner of Source: CITY OF PHILADELPHIA

Location of Source: UMBRIA + DOMINO Roxborough Section pencil of PHILADELPHIA



Observers Name: JAMES KEIL

Title: APCE 3 - CERTIFIED READER

Date: 12/4/84

Time interval: from 4:07 PM to ______

PART OF MINUTES

	0	1/4	1/2	3/4	.	0	1/4	1/2	3/4		0	1/4	1/2	3/4
0	0	0	0	0	20	0	0	0	0	40				
1	0	5	0	0	21	0	0	0	0	41				
2	0	0	5	5	430 22	0	0	0	0	42				
3	0	0	0	0	23	0	0	0	0	43				
4	0	0	0	0	24	0	0	0	0	44				
5	0	0	0	0	25	0	0	5	0	45				
6	5	0	0	5	26	0	5	0	0	46				
7	0	5	0	0	27	0	0	5	5	47				
8	10	5	5	5	28	0	0	0	0	48				
9	0	0	5	0	29	0	5	0	0	49				
10	0	5	5	10	30	0	0	0	0	50				
11	10	5	10	5	31	0	0	0	0	51				
12	5	5	5	10	440 32	0	0	0	0	52				
13	0	10	5	0	33	0	0	0	0	53				
14	0	0	0	0	34	0	0	0	0	54				
15	5	5	10	10	35	0	0	0	0	55				
16	10	10	5	10	36	0	0	0	0	56				
17	10	0	5	0	37	0	0	0	0	57				
18	0	0	0	0	38	0	0	0	0	58				
19	0	0	0	0	39	0	0	0	0	59				

Distance to source: Appx 150 yds

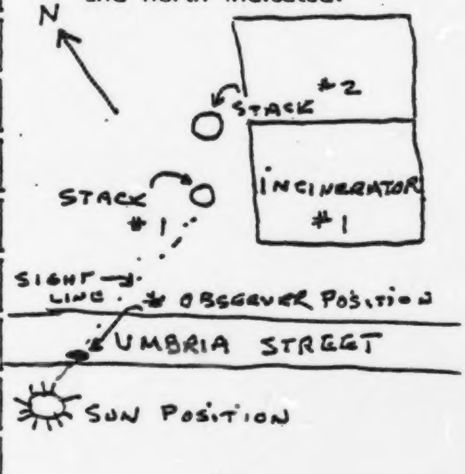
Wind speed and direction: FROM W-NW

Sky conditions: OVERCAST

Plume color: BROWN

Plume background: GRAY SKY

Sketch with source, observer, and north indicated:



SUMMARY

Opacity	No. of Readings	Total Minute
< 20%	160	40
> 20%	0	0
> 60%	0	0

CIN

Other Comments: PLUME RECORDED AT GAP BETWEEN THE STACK END + STEAM

EMISSIONS GONE STARTED

H1 FURNACE

CONTROL PANEL READINGS

12/5/84

IME	ATR "A" HOPPER TEMP (°F)	ATR "B" HOPPER TEMP (°F)	PPTR "A" FIELD PRIMARY VOLTAGE (VOLTS)	PRIMARY CURRENT (AMPS)	SECOND. CURRENT (mA)	"A" SPARK RATE (SPM)	PPTR "B" FIELD PRIMARY VOLTAGE (VOLTS)	PRIMARY CURRENT (AMPS)	SECOND CURRENT (mA)	"B" SPARK RATE (SPM)	INSULATOR BLOWER CURRENT (AMPS)
:00AM	220	160	250	120	480	32	190	40	160	28	21
:15	220	160	250	120	470	32	195	75	280	12	21
:30	220	160	250	115	440	22	180	40	240	32	21
:45	220	160	250	120	480	32	190	60	260	16	21
:00	220	160	250	130	520	20	190	90	320	32	21
:15	220	160	240	100	380	[illegible]	180	75	260	12	21
:30	220	160	250	125	480	[illegible]	200	80	300	32	21
:45	215	160	225	120	460	18	170	70	260	22	22
0:00	220	160	240	120	420	32	180	70	280	6	22
:15	220	160	250	120	460	26	180	60	250	30	22
:30	220	160	250	120	460	16	180	70	280	20	22
:45	220	160	240	120	460	26	180	80	280	28	22
:00	220	160	250	125	490	14	200	85	350	14	22
:15	220	160	255	130	500	32	195	80	290	16	22
:30	220	160	245	115	430	34	180	80	295	20	22
:45	220	160	230	115	430	24	185	90	320	20	21
:00	220	160	250	125	480	32	180	70	290	24	21
:15	220	160	250	120	450	18	180	80	320	20	21
:30	220	160	240	125	460	32	190	80	310	24	21
:45	220	160	250	115	480	16	180	75	280	30	21
:00	220	160	250	125	400	30	180	65	280	18	22
1:15	220	160	220	115	420	14	170	75	280	16	22
:30	220	160	220	120	460	30	180	75	280	8	22
:45	220	160	250	130	500	28	190	65	260	12	21
:00	220	160	240	125	480	28	180	75	280	8	21
:15	220	160	250	125	460	24	180	85	320	12	21
:30	220	160	250	120	420	24	180	80	320	12	21
:45	220	160	240	125	460	16	180	90	340	12	21
3:00	220	160	250	120	460	20	180	75	300	12	21

Reproduced from best available copy.

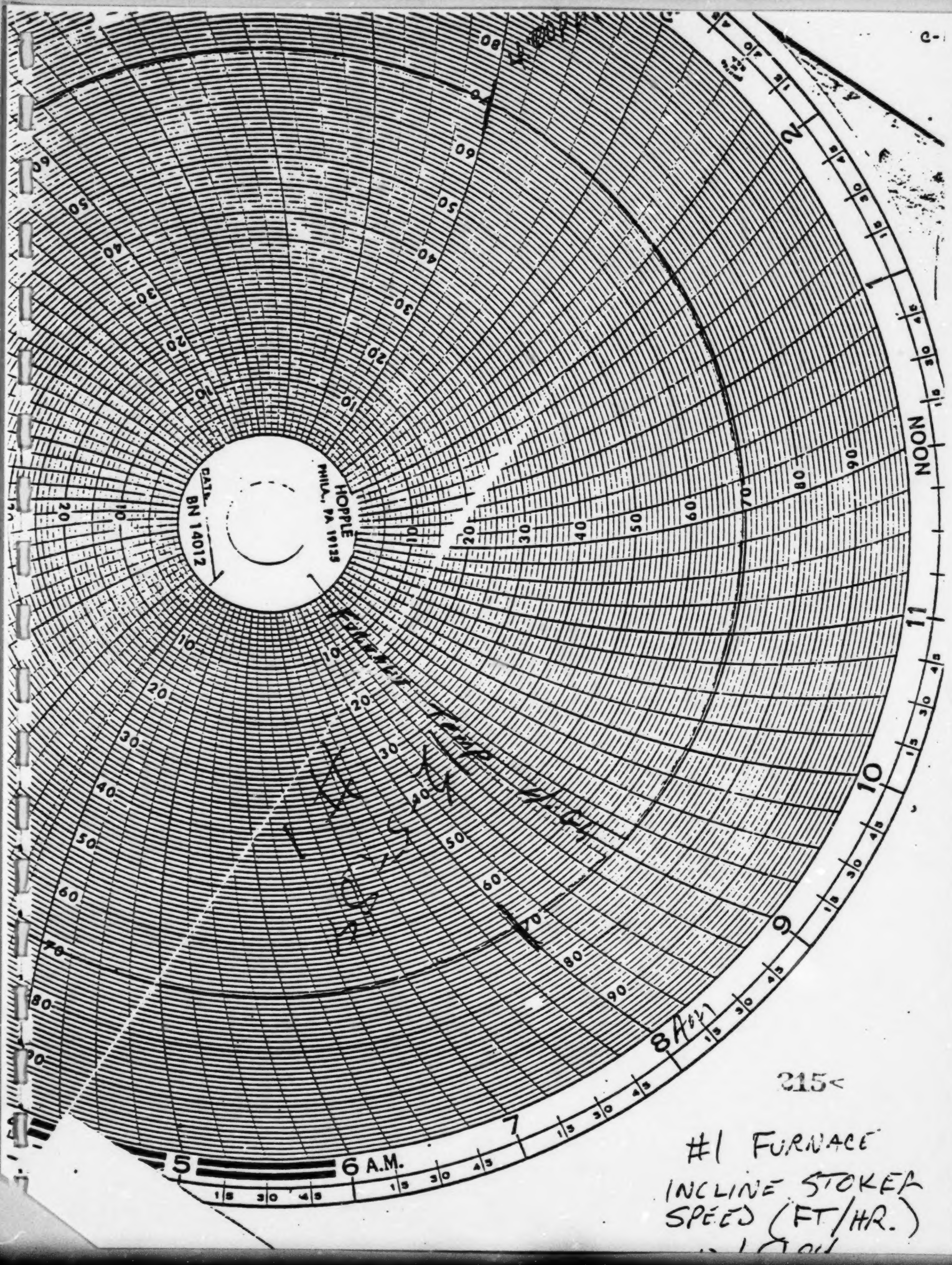
CONTROL PANEL READINGS

12/5/84

TIME	F.D. FAN CONTROL SETTING	FORCED DRAFT	FURNACE DRAFT	I.D. FAN CURRENT	INCLINE STOKER SPEED	HORIZ STOKER SPEED	FURNACE TEMP.	PPTR INLET TEMP	DAMPER POSITIONS *				QUENCH WATER FLOW RATE
									OVER FIRE	UNDER INCLINE	UNDERFIRE HORIZONTAL	UNDERFIRE VERTICAL	
	(PSI)	(IN. H_2O)	(IN. H_2O)	(AMPS)	(FPH)	(FPH)	(°F)	(°F)	1 2 3	1 2 3 4	1 2 3	4 5 6	(GPM)
8:00 AM	11.5	1.9	.4	275	70	82	1850	560	0 0 0	C000	2/3 1/3 0	0 1/2 C	112
8:15	11.5	1.9	.35	300	70	75	1850	560		C000	"	"	112
8:30	11.5	1.9	.4	250	70	75	1700	560		C000	"	"	90
8:45	14	1.9	.375	275	70	97	1825	555		C000	"	"	108
9:00	7	1.5	.4	250	3	100	2100	560		C000	2/3 0 0	C 1/3 C	104
9:15	10	1.8	.35	225	70	100	1500	440		C000	"	"	56
9:30	15	2.2	.375	260	70	100	1700	550	ALL 3 DAMPERS WIDE OPEN	C000	"	"	120
9:45	0	1.6	.35	200	70	100	1750	560		0000	2/3 0 0	C 1/4 C	116
10:00	20	2.5	.35	300	70	100	1750	560		0000	"	"	118
10:15	20	2.0	.35	270	70	100	1700	560		0000	"	"	100
10:30	20	2.1	.35	270	70	100	1750	560		"	"	"	100
10:45	20	2.1	.35	200	70	100	1600	550		"	"	"	70
11:00	20	2.3	.38	270	70	100	1680	560		"	3/4 0 0	C 1/4 C	92
11:15	20	2.3	.4	275	70	100	1650	560		"	"	"	110
11:30	20	2.3	.35	275	70	100	1660	560		"	"	"	96
11:45	20	2.4	.425	225	70	85	1575	560		"	3/4 0 0	C 1/4 C	76
12:00	20	2.4	.4	250	70	87	1650	560		"	"	"	108
12:15	20	2.4	.4	300	70	87	1750	565		"	"	"	116
12:30	20	2.2	.4	275	70	87	1700	560		"	"	"	108
12:45	20	2.2	.4	250	70	87	1650	560		"	"	"	90
1:00	20	2.2	.4	300	70	87	1750	550		"	"	"	122
1:15	20	2.2	.4	300	70	87	1750	550		"	"	"	92
1:30	20	2.8	.4	260	70	87	1600	550		"	3/4 2/3 C	C 1/4 C	96
1:45	20	2.8	.4	275	70	87	1700	555		"	"	"	100
2:00	20	2.8	.425	225	70	87	1550	560		"	"	"	80
2:15	20	2.8	.4	275	70	90	1650	565		"	"	"	124
2:30	20	2.8	.45	240	70	90	1650	560		"	"	"	84
2:45	20	2.8	.4	225	70	82	1725	560		"	"	"	102
3:00	20	2.7	.4	225	70	82	1700	560		"	"	"	100

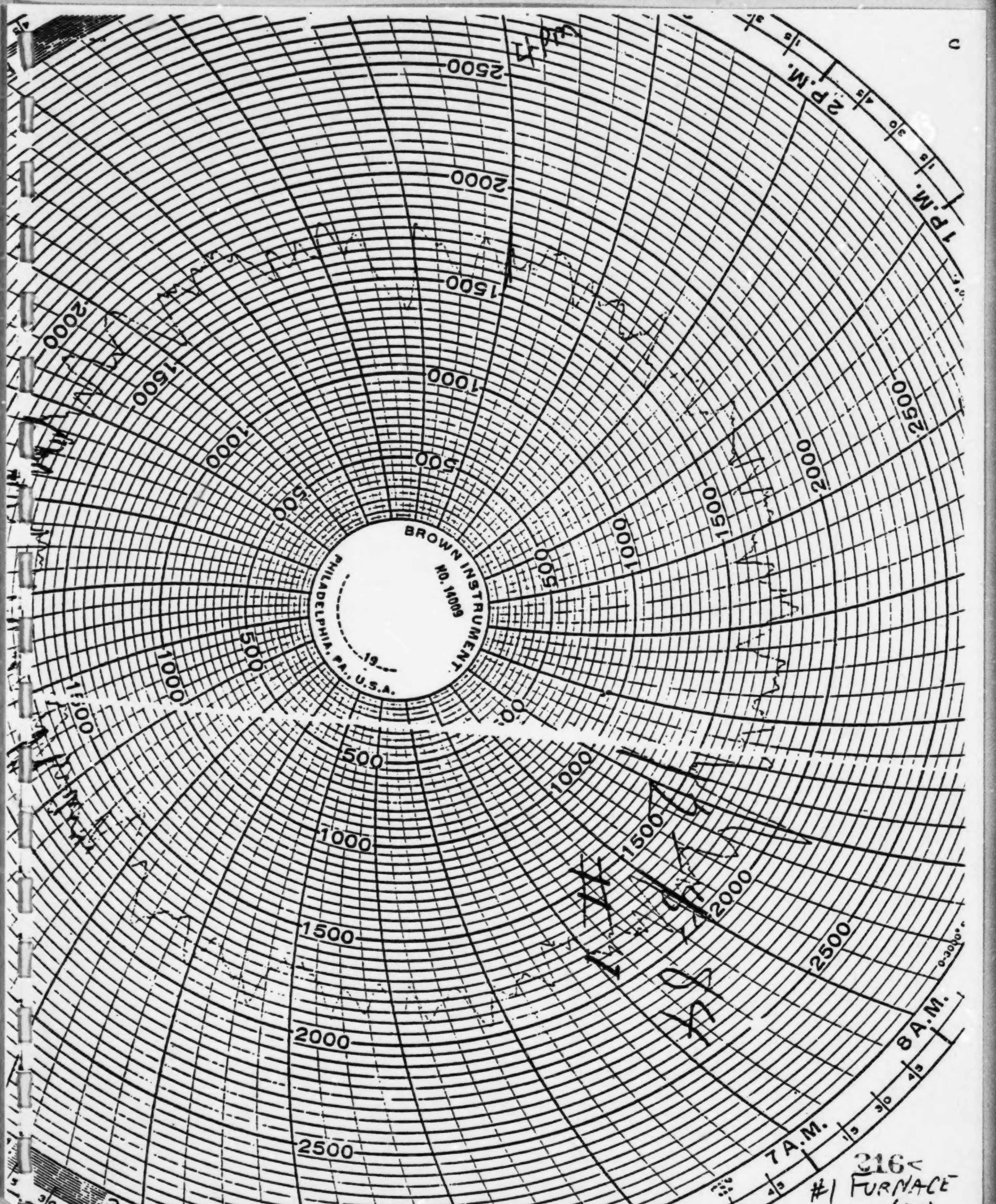
* DAMPER POSITIONS (NUMBER DESIGNATES
[illegible] FROM FAN END

C-1



215<

#1 FURNACE
INCLINE STOKER
SPEED (FT/HR.)



316<

#1 FURNACE
TEMP. (°F)
12/5/84

THEORETICAL AIR CALCULATIONS

I. Based on average characteristics of Municipal Solid Waste at Akron OH.

Moisture:	0.26 lb/lb waste
Ash:	0.258 lb/lb waste
Combustibles:	0.482 lb/lb waste

It is assumed that combustibles consist of cellulose type waste and PVC type plastics.

PVC:	0.05 lb/lb waste
Cellulose:	0.432 lb/lb waste
BTU as Received:	4100 Btu/lb

Combustion Air Requirements:

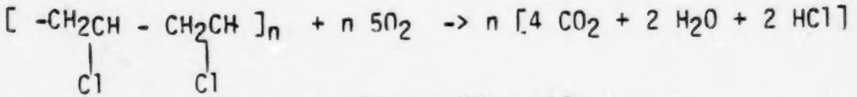
A. Cellulose: O_2 in air combines with cellulose stoichiometrically

$$\begin{array}{rlllll} & C_6H_{10}O_5 & + 6O_2 & \rightarrow 6CO_2 & + & 5H_2O \\ & 162 & + 192 & \rightarrow 264 & + & 90 \\ & 1 & + 1.185 & \rightarrow 1.63 & + & 0.555 \\ \text{As received lb.} & 0.432 & + 0.512 & \rightarrow 0.704 & + & 0.24 \end{array}$$

1 lb O_2 requires 4.32 lb air

$0.512 \times 4.32 = 2.2\ 12$ lb air reqd.

B. PVC



$$[-CH_2\underset{|\atop Cl}{CH} - CH_2\underset{|\atop Cl}{CH}]_n + n\,5O_2 \rightarrow n\,[4\,CO_2 + 2\,H_2O + 2\,HCl]$$

$$\begin{array}{rllll} & n\,125 & + n\,160 & \rightarrow n\,176 + n\,36 + n13 \\ & 1 & + 1.28 & \rightarrow 1.408 + 0.288 + 0584 \\ \text{As received lb} & 0.05 & + 0.064 & \rightarrow 0.0704 + 0.0144 + 0.0292 \end{array}$$

$0.064 \times 4.32 \dfrac{\text{lb air}}{\text{lb } O_2} = 0.2765$ lb air reqd.

Total stoichiometric air reqd: 2.212 + 0.2765 = 2.489 lb

Feed rate : 15.9 tons/hr.

Stoichiometric air = $\dfrac{2.489 \times 15.9 \times 2000}{60} = 1318.9$ lb/min

One mole of any gas occupies 359ft^3 at 14.7 psia and 32°F

Stoich. air volume: $1318.90 \times \dfrac{359}{28.84} \times \dfrac{530}{492} = 176857$ scfm

Total forced draft air = 40000 scfm
Excess air = 40000 - 17686 = 223143 scfm
% excess air = 126%

Products of Combustion (PC):

		Cellulose		PVC	
Dry Gas:	CO_2	0.704	+	0.0704	= 0.7744 lb/lb waste
	N_2	2.4885	-	(0.512 + 0.064)	= 1.9125 lb/lb waste
Moisture:	H_2O from waste				= 0.26 lb
	H_2O from air: 2.4885 x 0.0063				0.0156 lb
0.0063 lb	H_2O/lb dry air @ 60% RH + 60°DB				
	H_2O from combustion 0.24 + 0.0144				0.2544 lb
	HCl				0.0292 lb
					3.2461 lb

Material Balance Verification:

PC	3.2461 lbs		Waste	1.00 lb
Ash	0.258 lb		Stoch. Air	2.4885 lbs
	3.5041 lbs		H_2O Air	0.0156 lb
				3.5041 lbs

Volume PC Converted to Std Conditions (70°F 14.7 psia)

Product	Weight (lb/min)	Volume (scfm)
CO_2	$\frac{0.7744 \times 15.9}{60} \times 2000$	3607.4
N_2	$\frac{1.9125 \times 15.9}{60} \times 2000$	13999.9
H_2O	$\frac{0.53 \times 15.9}{60} \times 2000$	6035.1
Air		22314.3
HCl	$0.0292 \times \frac{15.9}{60} \times 2000$	163.97
		46120.67 scfm
	Total Exhaust	67000 scfm
	Air leak	20879.33 scfm

Heat Balance:

Heat Input 4100 Btu/lb

Heat losses: (assume 1800°F outlet temp rel to 60°F)

	lb/lb waste enthalpy (Btu/lb)	
Moisture:	0.53 x 1948.02	= 1032.45 Btu/lb waste
CO_2:	0.7744 x 469.1	= 363.27
N_2	1.9125 x 464.8	= 888.93
Ash	0.258 x 377.6	= 97.42
HCl	0.0292 x 469.1	= 13.70
Radiation 10% of input		= 410.00
		2805.77

Excess Heat: 4100-2805.77 = 1295.23 Btu/lb waste

Excess air requirement $\frac{1294.23 \text{ Btu/lb waste}}{453.24 \text{ Btu/lb}}$ = 2.855 lb/lb waste

Excess air reqd. volume: $2.855 \times \frac{15.9}{60} \times 2000 \times \frac{359}{28.84} \times \frac{530}{492}$ = 20294 scfm

II. Data: Fuel Analysis

(Ref: p. 658 1984 National Waste Processing ASME Conference Proceedings)

Carbon - 28.6%
Moisture - 28.8%
Ash - 21.8%
Sulfur - 0.1%
Cl_2 - 0.3%
HHV as fired - 4600 Btu/lb

Due to low contents of chlorine and sulfur the entire combustibles are assumed to be cellulose type

Moisture - 0.288 lb/lb waste
Ash - 0.218 lb/lb waste
$C_6H_{10}O_5$ - 0.494 lb/lb waste

$$C_6H_{10}O_5 + 6O_2 \rightarrow 6CO_2 + 5H_2O$$
$$162 + 192 \rightarrow 264 + 90$$
$$1 + 1.185 \rightarrow 1.63 + 0.555$$

As received lb $0.494 + 0.585 \rightarrow 0.805 + 0.274$

1 lb O_2 requires 4.32 lb air

0.585 x 4.32 = 2.527 lb air reqd.

Feed rate : 15.9 tons/hr.

$$\text{Stoichiometric air} = \frac{2.527 \times 15.9 \times 2000}{60} = 1339.42 \text{ lb/min}$$

One mole of any gas occupies 359ft^3 at 14.7 psia and 32°F

$$\text{Stoich. air volume: } 1339.42 \times \frac{359}{28.84} \times \frac{530}{492} = 17961 \text{ scfm}$$

Total forced draft air = 40,000 scfm
Excess air = 22,039 scfm
% excess air = 123%

Products of Combustion (PC)

Dry Gas	CO_2:	0.805 lb/lb waste
	N_2:	1.942 lb/lb waste
Moisture	H_2O from waste:	0.288 lb/lb waste
	H_2O from air: 2.527 x 0.0063 =	0.016 lb/lb waste
0.0063 lb	H_2O/lb dry air @ 60% RH + 60°DB	
	H_2O from combustion:	0.274 lb/lb waste
		3.325 lb/lb waste

Mass Balance Verification:

PC	3.325 lbs	Waste	1.00 lb
Ash	0.218 lb	Stoich. Air	2.527 lbs
	3.543 lbs	H_2O Air	0.016 lb
			3.543 lbs

Volume PC Converted to Std Conditions (70°F, 14.7 psia)

Product	Weight (lb/min)	Volume (scfm)
CO_2	$\frac{0.805 \times 15.9}{60} \times 2000$	3749.9
N_2	$\frac{1.942 \times 15.9}{60} \times 2000$	14215.8
H_2O	$\frac{0.578 \times 15.9}{60} \times 2000$	6581.7
Air		22039.0
		46586.4
	Total Exhaust:	67000
	Air leak:	20414

Heat Balance:

Heat Input: 4600 Btu/lb

Heat Losses: (assume 1800°F outlet temp rel to 60°F)
lb/lb waste enthalpy (Btu/lb)

Moisture:: 0.578 x 1948.02 = 1125.96 Btu/lb waste
CO_2 : 0.895 x 469.1 = 377.63 Btu/lb waste
N_2 : 1.942 x 464.8 = 902.64 Btu/lb waste
Ash : 0.218 x 377.6 = 82.32 Btu/lb waste
Radiation (10% of input) = 460.00 Btu/lb waste
2948.55 Btu/lb waste

Excess Heat: 4600-2948.55 = 1651.45 Btu/lb waste

Excess Air Read = $\frac{1651.45 \text{ Btu/lb waste}}{453.24 \text{ (Btu/lb)}}$ = 3.64 lb/lb waste

Excess air volume reqd: 25895 scfm

III. Based on Essex County, NJ Data:

Moisture:	23% by wt.	Btu/lb: 5475	
Ash:	21%		
Combustibles:	56%	Plastics (PVC)	5%
		Cellulose	51%

Entire plastics portion is assumed to be polyvinyl chloride and the rest of the combustibles is assumed to be cellulose type waste.

Combustion Air Requirements:

Oxygen in air is assumed to combine with cellulose stoichiometrically.

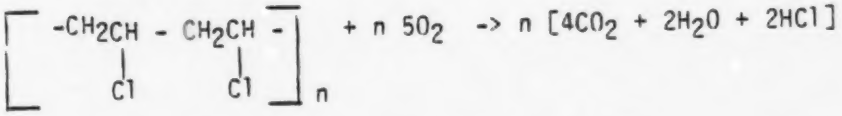
A. Cellulose waste

$$\begin{array}{lrcrcl} & C_6H_{10}O_5 & + 6O_2 & \rightarrow 6CO_2 & + & 5H_2O \\ & 162 & + 192 & \rightarrow 264 & + & 90 \\ & 1 & + 1.185 & \rightarrow 1.63 & + & 0.555 \\ \text{As received lb.} & 0.51 & + 0.604 & \rightarrow 0.831 & + & 0.283 \end{array}$$

1 lb O_2 requires 4.32 lb air

For each lb of waste: 0.604 x 4.32 = 2.609 lb air reqd.

B. PVC



$$\left[-CH_2\underset{\displaystyle Cl}{\underset{|}{CH}} - CH_2\underset{\displaystyle Cl}{\underset{|}{CH}} - \right]_n + n\ 5O_2 \rightarrow n\ [4CO_2 + 2H_2O + 2HCl]$$

$$\begin{array}{lrcrcc} & n\ 125 & + n\ 160 & \rightarrow n\ 176 & + n\ 36 & + n\ 73 \\ & 1 & + 1.28 & \rightarrow 1.408 & + 0.288 & + 0.584 \\ \text{As received lb} & 0.05 & + 0.064 & \rightarrow 0.0704 & + 0.0144 & + 0.0292 \end{array}$$

$$0.064 \times 4.32 \frac{\text{lb air}}{\text{lb } O_2} = 0.2765 \text{ lb air reqd.}$$

Total theoretical air reqd: 2.609 + 0.2765 = 2.8855 lb

Products of Combustion (PC)

		Cellulose	PVC	
Dry Gas	CO_2	0.831	+ 0.0704	= 0.9014 lb/lb waste
	N_2	2.8855	- (0.604 + 0.064)	= 2.2175 lb/lb waste
Moisture	H_2O from waste			= 0.23 lb/lb waste
	H_2O from air: 2.8855 x 0.0094			= 0.0271 lb/lb waste
0.0094 lb	H_2O/lb dry air @ 60% RH + 70°DB			
	H_2O from combustion			0.2974 lb/lb waste
	HCl	0.283 + 0.0144		
				0.0292 lb/lb waste
				3.7026 lb/lb waste

Feed rate : 15.9 tons/hr.
Theoretical air = 2.8855 x 15.9 x 2000

$$= 91758.9 \frac{\text{lb}}{\text{hr}} \text{ or } 1529.315 \frac{\text{lb}}{\text{min}}$$

One mole of any gas occupies 359ft^3 at 14.7 psia and 32°F

Theoritical air volume: $1529.315 \frac{\text{lb}}{\text{min}} \times \frac{359}{28.84} \times \frac{(460 + 70)}{(460 + 32)} = 20507.23$ scfm

Total forced draft air = 40,000 scfm

$$\% \text{ excess air} = \frac{40{,}000 - 20507.23}{20507.23} \times 100 = 95\%$$

Excess air: 40000 - 20507.23 = 19492.77 scfm

Volume PC Converted to Std Conditions (70°F 14.7 psia)

Products	Weight (lb/min)	Volume (scfm)
CO_2	$\frac{0.9014 \times 15.9}{60} \times 2000$	4199
N_2	$\frac{2.2175 \times 15.9}{60} \times 2000$	16232.55
H_2O	$\frac{0.5545 \times 15.9}{60} \times 2000$	6314
Air	19492.77 scfm	19492.77
HCl	$0.0292 \times \frac{15.9}{60} \times 2000$	163.97
		46402.3 scfm
	Total Exhaust	67000 scfm
	Air leak	20597.7 scfm

Heat Balance

Heat Input: 5475 Btu/lb waste

Heat losses:	lb/lb waste enthalpy (Btu/lb)	
Moisture:	0.5545 x 1948.02	= 1080.18 Btu/lb waste
CO_2:	0.9014 x 469.1	= 422.85 Btu/lb waste
N_2	2.2175 x 464.8	= 1030.69 Btu/lb waste
Ash	0.21 x 377.6	= 79.30 Btu/lb waste
HCl	0.0292 x 469.1	= 13.70 Btu/lb waste
Radiation loss		= 547.50 Btu/lb waste
		3174.22 Btu/lb waste

Excess Heat: 5475-3174.22 = 2300.78 Btu/lb waste

Excess air reqd. volume: $\frac{2.300.78 \text{ Btu/lb waste}}{453.24 \text{ Btu/lb}} = 5.076 \frac{\text{lb}}{\text{lb waste}} = 36077$ scfm

IV. Data: Ultimate Analysis of Refuse

(Ref: p. 228 1984 National Waste Processing ASME Conference Proceedings)
Calculated from performance test data.

Carbon - 0.2472 lb/lb waste
Hydrogen - 0.03484
Sulfur - 0.011
Moisture - 0.2774
Nitrogen - 0.006
Ash - 0.21817
Oxygen - 0.21529
Heat Content - 4443 Btu/lb

Combustion Calculation:

$$\begin{array}{lccccc} & C & + & O_2 & \rightarrow & CO_2 \\ & 12 & + & 32 & \rightarrow & 44 \\ & 1 & & 2.666 & & 3.666 \\ \text{As received lb} & 0.2472 & & 0.6592 & & 0.9064 \end{array}$$

0.2472 lb C requires 0.6592 lb Oxygen or 2.848 lb air

$$\begin{array}{lccccc} & 2H_2 & + & O_2 & \rightarrow & 2H_2O \\ & 4 & + & 32 & & 36 \\ & 1 & & 8 & & 9 \\ \text{As received lb} & 0.03484 & & 0.279 & & 0.3136 \end{array}$$

0.03484 lb H requires 0.279 lb Oxygen or 1.205 lb air

$$\begin{array}{lccccc} & S & + & O_2 & \rightarrow & SO_2 \\ & 32 & & 32 & & 64 \\ & 1 & & 1 & & 2 \\ \text{As received lb} & 0.011 & & 0.011 & & 0.022 \end{array}$$

0.011 lb S requires 0.011 lb O_2
= 0.0475 lb air

Total O_2 required : 0.6592 + 0.279 + 0.011
= 0.9492 lb
Less O_2 in waste 0.21529 lb
= 0.73391 lb O_2
= 3.17 lb air

Required stoichiometric air - 3.17 lb
Feed rate : 15.9 tons/hr.

$$\text{Stoichiometric air} = \frac{3.17 \times 15.9}{60} \times 2000 \times \frac{359}{28.84} \times \frac{530}{492} = 22533 \text{ scfm}$$

Total forced draft air = 40,000 scfm
Excess air = 40,000 - 22,533 = 17,467 scfm

$$\text{\% excess air} = \frac{40{,}000 - 22533}{22533} \times 100$$

$$= 77.5\%$$

Products of Combustion

CO_2: 0.9064 lb/lb waste
SO_2: 0.022 lb/lb waste
H_2O from combustion: 0.3136 lb/lb waste
H_2O from waste: 0.2774 lb/lb waste
H_2O from air (Stoich.): 0.0298 lb/lb waste
N_2 from waste: 0.006 lb/lb waste
from air: 2.436 lb/lb waste

Volume		scfm
CO_2	$\frac{0.9064 \times 15.9}{60} \times 2000$	4222.3
SO_2	$\frac{0.022 \times 15.9}{60} \times 2000$	70.5
H_2O	$\frac{0.6208 \times 15.9}{60} \times 2000$	7069.0
N_2	$\frac{2.442 \times 15.9}{60} \times 2000$	17876.6
Air	40,000 - 22532.7	17467.3
		46705.7
	Total Exhaust	67000
	Air leak	20294

--x--

Heat Balance

Heat Input: 4443 Btu/lb waste
Heat losses: (assume 1800°F outlet temp rel to 60°F)

	lb/lb waste		enthalpy (Btu/lb)	
Moisture:	0.6208	x	1948.02	= 1209.33 Btu/lb waste
CO_2 :	0.9064	x	469.1	= 425.19 Btu/lb waste
N_2 :	2.442	x	464.8	= 1135.04 Btu/lb waste
Ash :	0.21817	x	377.6	= 82.38 Btu/lb waste
Radiation loss (10% of input)				= 444.30 Btu/lb waste
				3296.24 Btu/lb waste

Excess Heat: 4443-3296.24 Btu/lb waste

= 1146.76 Btu/lb waste

$= 1146.76 \times \frac{15.9 \times 2000}{60}$

= 607782.36 Btu/min

Excess air requirement: $\frac{607782.36}{453.24 \frac{\text{Btu}}{\text{lb}}} = 1340.97 \frac{\text{lb}}{\text{min}}$

= 17982 scfm